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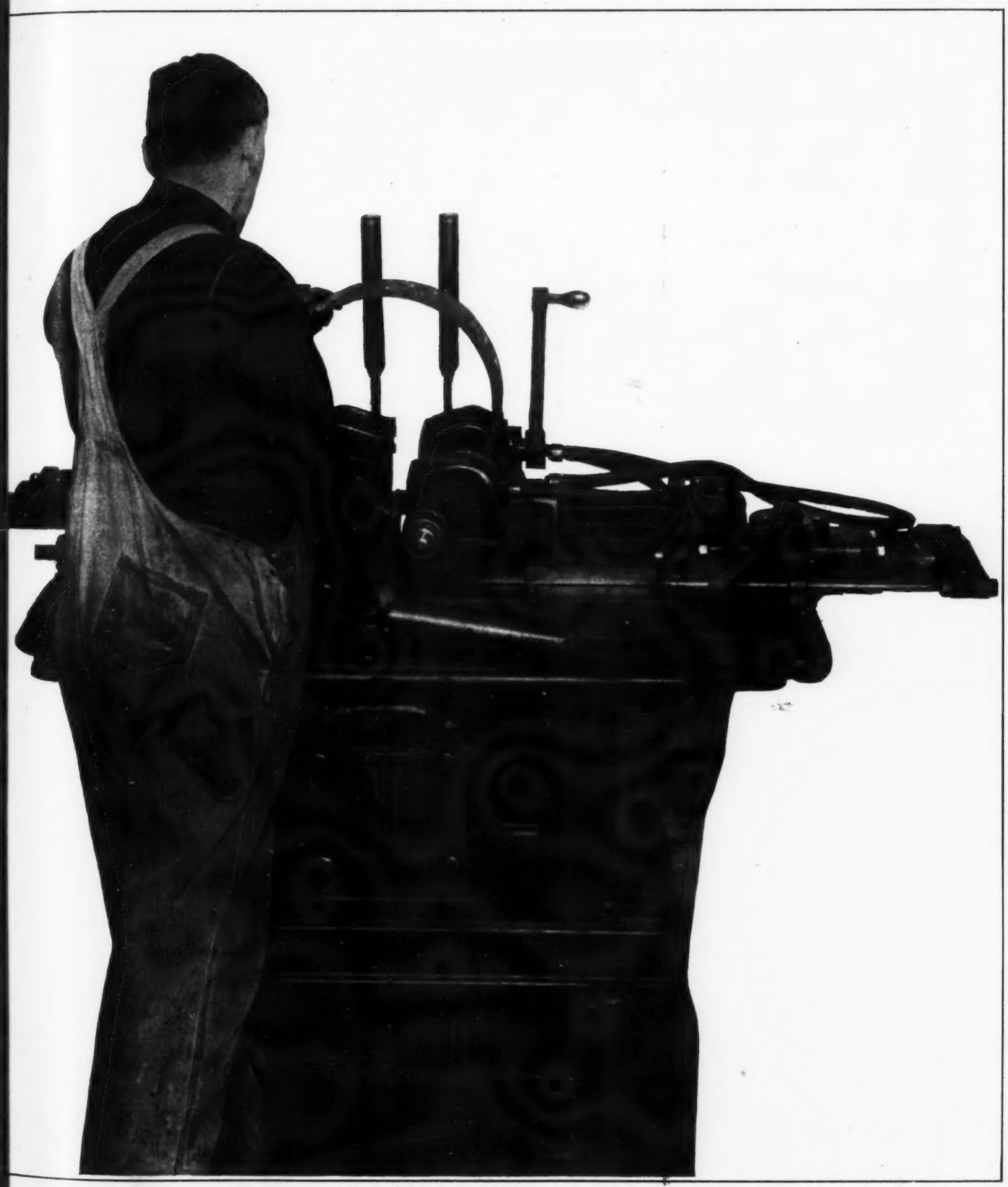


Seven Thousand Watts Applied for Fifty Seconds to Weld a Heavy Iron Ring.

WELDING BY ELECTRICITY—[See page 100.]

The Manufacture and Application of Nitrous Oxide

By A. S. Neumark

I.

NITROUS oxide, also known as laughing gas, was first obtained by Priestley in 1772, who called it "dephlogisticated nitrous gas;" in 1800 Davy published the first researches upon this gas.

PROPERTIES.

Nitrous oxide is a colorless gas of sweetish taste, and of a faint but pleasant odor. In its chemical action it closely resembles oxygen, as it easily breaks up into its constituents, nitrogen and oxygen. It supports combustion almost as effectively as does the latter gas; combustible substances, such as glowing charcoal, burning sulphur or phosphorus burn in N_2O with great brilliancy; a freshly extinguished taper is rekindled when thrust into the gas. The latter can, however, be distinguished from oxygen by the fact that it does not form brown vapors of nitrogen oxide when brought into contact with colorless nitrogen dioxide. Like acetylene, nitrous oxide is an enthodermic compound and, therefore, is liable to form explosive mixtures. Such a mixture is formed for example by equal parts of N_2O and hydrogen gas. The specific gravity of N_2O is 1.527, and its molecular weight is 44. The critical temperature is given by Dewar, as 37.4 deg. Cent., and the critical pressure as 75.0 atmospheres. Villard gives 38.8 deg. Cent. and 77.5 atmospheres, respectively. At 0 deg. Cent. and 30 atmospheres (450 pounds) pressure, N_2O liquefies to a colorless, mobile liquid, miscible with alcohol and ether. When liquid nitrous oxide is evaporated *in vacuo*, a temperature of —140 deg. Cent. may be obtained; its tension, according to Regnault, at 0 deg. Cent. is 36.1 atmospheres, or 49.8 atmospheres at 15 deg. Cent.; at —115 deg. Cent. it solidifies. Nitrous oxide is absorbed by cold water in considerable quantities, the warmer the water the less is dissolved or retained in solution. According to Bunsen, one part (by volume) of water at a temperature of 0 deg. Cent. and at normal barometric pressure dissolves 1.3052 parts of nitrous oxide; at 10 deg. Cent. it dissolves 0.9196 parts, and at 25 deg. Cent., 0.5962 parts. In alcohol the gas is still more soluble.

METHODS OF PREPARATION.

Priestley obtained the gas by the action of nitric oxide on moist iron filings and on liver of sulphur. It has subsequently been prepared by a number of methods, although only two of these are employed in the manufacture of nitrous oxide. The following are the methods by which it may be obtained:

1. By the reduction of nitric oxide by sulphuretted hydrogen, sulphides and sulphites, iron sulphate, etc.

2. By dissolving iron, tin or zinc in much diluted nitric acid, also copper at a temperature of 10 deg. Cent.

3. By dissolving zinc in a mixture of equal volumes of nitric and sulphuric acid, the concentrated acids being diluted with 9 to 10 parts of water.

4. By the action of a mixture of sulphuric acid (1 part), nitric acid (2 parts), and water (3 parts) on tin. Pure nitric oxide is evolved without the intervention of heat.

5. By heating salammoniac with nitric acid at 100 deg. Cent.

6. By boiling a mixture of 5 parts of stannous chloride, 10 parts of hydrochloric acid (sp. gr. 1.21) and 0.9 parts of nitric acid (sp. gr. 1.38). This process has been proposed by Campari in 1888. The proportions given must be adhered to, or the gas is liable to be evolved with explosive irregularity.

7. If a concentrated aqueous solution of hydroxylamin sulphate and sodium nitrate are intermixed, heating takes place under evolution of pure N_2O.

8. By the decomposition of ammonium nitrate by heat. If this salt is heated to about 180 deg. Cent. (356 deg. Fahr.), it melts, and on further raising the temperature it breaks down into nitrous oxide and water: $NH_4NO_3 = N_2O + 2H_2O$.

9. By heating a mixture of ammonium sulphate and sodium nitrate: $2NaNO_3 + (NH_4)_2SO_4 = Na_2SO_4 + 4H_2O + 2N_2O$. Nitrate of lead may be substituted for the sodium nitrate (Smith and Elsmore Patent).

10. By heating a mixture of potassium nitrate and salammoniac. This method, which has been proposed by Gravette, has been found uncertain, and the yield of gas unsatisfactory.

11. By the action of formic acid on alkali nitrate (A. Quartaroli). The nitrate is added little by little and the mixture is slightly warmed: $2KNO_3 + 4OHCOOH = N_2O + 4CO_2 + 5H_2O + 2HCOOK$. The carbon dioxide, simultaneously set free, is removed by passing through a solution of caustic potash, warmed to 40 deg. Cent.

12. K. Soderman proposes to prepare the gas from atmospheric air with the aid of extreme high temperatures. R. P. Pictet proposed the use of oxy-acetylene flame on a current of oxygen (55 parts) and nitrogen (45 parts).

13. R. Marston, according to an English patent, obtains nitrous oxide or a mixture of the latter with nitrogen, by passing air and hydrogen (or air and gaseous or other compounds of nitrogen and hydrogen) through tubes or retorts containing oxidizable substances heated at high temperature. The resulting gases, nitrogen and nitrous oxide, are separated by the joint agency of liquefaction and gravitation, exercised within a suitable vessel.

THE MANUFACTURE OF NITROUS OXIDE.

The method usually employed for the manufacture of nitrous oxide is to decompose ammonium nitrate. This method has been known since 1793, when the Dutch chemists, Derman, van Trooswyk, Niewvland, Bont, and Sonwernburgh first obtained the gas in this manner. Nitrous oxide, prepared from nitrate of ammonia NH_4NO_3, is the cheapest and most satisfactory as in the decomposition of the nitrate not only all the nitrogen of the nitric acid enters into the composition of the N_2O produced, but also that of the ammonia. Theoretically 1 pound of nitrate should yield about 32½ gallons (or 0.55 pound) of nitrous oxide, in practice a loss of 10 per cent may be figured on. For the production of the gas which is to be liquefied only the very purest of nitrate of ammonia can be used. The presence of other gases would make liquefaction difficult, if not impossible. Above all the nitrate must be *absolutely* free from salammoniac, as this salt would cause the formation of chlorine, which even by repeated washings can not wholly be eliminated. The apparatus used for generating nitrous oxide, as devised by the writer, consists of a cast iron retort (preferable porcelain-lined), provided with a hand-hole and topped by a "gooseneck" or dome, which serves to take care of sudden expansion and also helps in condensing the steam arising during operation. From the delivery tube the gas passes through a cooling device, either a Liebig condenser, as shown in Fig. 1, or a receiver set into a tub filled with cold water. This arrangement is quite necessary, as otherwise the aqueous vapors, intermixed with the gas, would condense in the wash-bottles, which would soon be completely filled up, and thus made useless. From the receiver the nitrous oxide passes through several washbottles, for even with the greatest care and using the purest nitrate the gas is likely to contain impurities, such as chlorine, ammonia, carbon dioxide, nitric oxide and nitrogen peroxide. The first of the washbottles, or scrubbers, should contain an aqueous solution of copperas, the second one an emulsion made of a solution of copperas and concentrated sulphuric acid, the third bottle a solution of caustic soda, and the fourth bottle should be filled with pure water. The ends of the inlet tubings should be bent, perforated or jagged to compel breaking up of the large gas bubbles, and thus insure a more complete washing. At least one, but preferably all of the washbottles, should be provided with a safety tubing to indicate and take care of any back-pressure. Before charging the retort, the nitrate should be dried at a temperature of at least 200 deg. Fahr. The perfectly dry salt is then heated until ebullition occurs. Not more than 30 to 35 pounds, even for the largest size retort, should be used at a time. Like all ammonia salts, ammonium nitrate is volatile under the influence of heat, and if the latter is not carried rapidly to such a degree as is necessary to start decomposition, a portion of the salt will volatilize. At a temperature between 275 deg. and 300 deg. Fahr. the nitrate sublimes without decomposition or without becoming fluid. At 320 deg. Fahr. it melts, while sublimation continues, and decomposition sets in. Between 340 deg. and 480 deg. Fahr. decomposition into N_2O and aqueous vapor proceeds rapidly and is followed by free ebullition. The heat must *never* be allowed to rise above 480 deg. Fahr.; it should be kept at a temperature between 450 deg. and 480 deg. Fahr., or else the

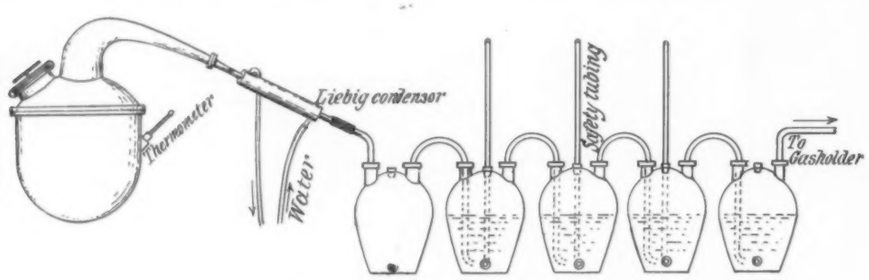


Fig. 1.—The Generator and Washers.

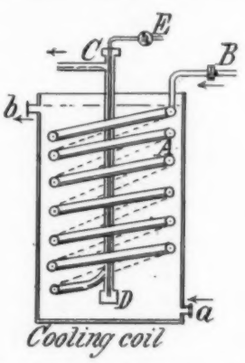


Fig. 2.—The Cooling Apparatus.

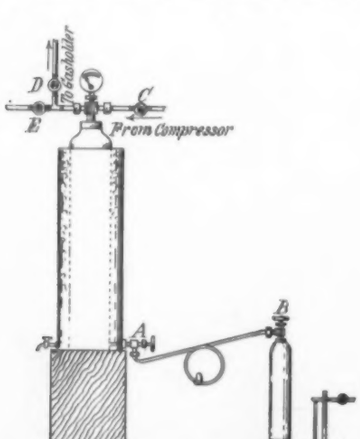


Fig. 3.—The Liquefier.

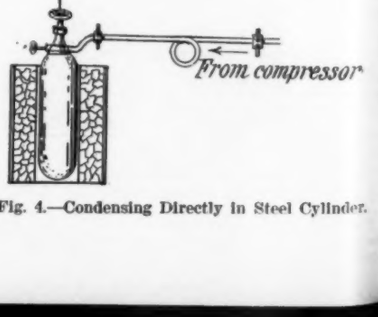


Fig. 4.—Condensing Directly in Steel Cylinder.

decomposition will be accompanied by exothermic effects, and the reaction become self-accelerating and uncontrollable. A vivid luminescence then spreads throughout the mass, and the gas is evolved with explosive violence. Reddish brown fumes of nitrogen oxide are formed and the nitrate will be wholly resolved into NO_2, NO_2, H_2O, O_2 and N. The oxygen and nitrogen cannot be removed, and will make liquefaction impossible. The nitrogen dioxide and other nitric gases which may be formed are irritant, irrespirable and poisonous. It is, therefore, necessary that in case of overheating the supply of heat be shut off and connection with the gas holder be broken at once. A stream of compressed air, directed against the retort, will quickly restore normal conditions. By mixing the dry nitrate with dry sea sand, overheating may be prevented and the temperature may be carried to 500 deg. or 520 deg. Fahr.

SMITH AND ELSMORE'S METHOD.

Another method for the manufacture of nitrous oxide is the one proposed by Smith and Elsmore in 1892. A mixture of 17 parts (by weight) of dry sodium nitrate —or 20 parts of potassium nitrate—and 13 to 14 parts of ammonium sulphate is first heated to 460 deg. Fahr., but toward the end of the process the temperature may be raised to 570 deg. Fahr. This is a more economical manner of producing the gas than the one first described, as the cost of materials is less than that of ammonium nitrate. The yield of nitrous oxide is, however, a little below that obtained by the action of heat upon an equivalent amount of ammonium nitrate. The reaction proceeds smoothly throughout and, therefore, requires less attention. Three washbottles, containing sulphuric acid, caustic soda lye and pure water, are sufficient to remove impurities. Toward the end of the reaction nitric oxide is evolved in both the methods here described; generation should, therefore, never be carried to the very end, but should be stopped the moment brown fumes appear at the delivery tube. The exit pipe from the last washbottle is connected with the gas holder, where the gas is collected over brine. In former days nitrous oxide was manufactured in the dentist's laboratory, and the gas used taken directly from the gas holder. For inhalation purposes, nitrous oxide must be absolutely free from impurities, such as Cl, NO, NO_2, NH_3, etc. To assume that a dentist or surgeon be a chemist as well, would be asking too much; and several cases of death during nitrous oxide anæsthetization have been due to impure gas. Even traces of chlorine or nitric oxide may make the gas useless and dangerous for inhalation. It is also claimed that deterioration of the gas follows its preservation over a tank of water. However, when nitrous oxide was manufactured in the chemical laboratory and brought on the market in the liquid state, stored in steel cylinders of a portable form, it soon won the general reputation of being the dental anæsthetic *par excellence*.

The condensing pump used for compression must be constructed with utmost precision of adjustment to prevent wastage of gas. The same precaution as used for compressing oxygen must be followed; oil or other carbonaceous lubricants must not be used; diluted glycerine may be employed instead. The pump, which has two stages of compression, must be provided with intercooling to prevent heating of the cylinders. The latter should also be submerged in water. Before entering the first stage of compression, the gas should be allowed to pass through a condensing coil, cooled with ice, to remove any water present, and also to act as an auxiliary cooler for the condensing pump. After leaving the latter the nitrous oxide passes another cooling apparatus, the construction of which is shown in Fig. 2. *A* is the condensing coil made of copper, 1/16 inch diameter and fastened to the tank in such a manner that it can easily be removed. The gas enters at *B* and leaves the coil at *C*. The tank is kept filled with cold water entering at *a* and running off at *b*. At the lowest end of the coil is a small receptacle *D*, where the lubricant from the compressor, carried along by the gas, is deposited. It is removed from time to time by a narrow tubing leading from *D* to valve *E*. On opening the latter, the pressure of the gas forces the glycerine out of the receptacle.

From the cooling apparatus the nitrous oxide passes to the liquefier (Fig. 3). The latter consists of a large cylindrical storage tank, provided with a gage and the valves *A*, *C*, *D* and *E*. The cylinder is placed in a sheet iron tank filled with chopped ice mixed with rock salt. Other means of cooling may be used to advantage, such as liquid ammonia, carbon dioxide or "Pictet Liquid" (liquid sulphur dioxide mixed with a small percentage of carbon dioxide). At a temperature of — 80 deg. Cent. a pressure of but 12 atmospheres (180 pounds per square inch) is required for liquefaction; at 0 deg. Cent. the pressure necessary is 36 atmospheres (540 pounds), while if only cold water is used as a cooling agent the pressure required would be 60 atmospheres (900 pounds). These figures are for N_2O, free from any impurities. From the storage tank the liquid N_2O is drawn off into the small steel bottles, resting on a scale. The filling device, attached to the bottom of the tank consists merely of an elastic piece of copper tubing. Connection with the tank is made by means of couplings, and the valves *A* and *B* (Fig. 3) are opened. One hundred gallons of liquid N_2O weigh about 26 ounces. To force all the liquid out of the large storage tank, the ice should be removed and replaced by warm or hot water; in this manner the desired excess pressure is obtained. For cleaning or other purpose the gas in the large tank may be emptied into the gasometer by opening valve *B*, while small amounts of foreign gases may be removed by "blowing off" through *E*. The storage tank may be dispensed with altogether by allowing liquefaction to take place within a small steel cylinder (Fig. 4). The latter is kept suspended on a spring-scale and placed in a receptacle surrounded by any of the cooling agents already named. The steel cylinders are tested to a pressure of at least 180 atmospheres; in the Germany the law requires that they be tested every 3 years to 250 atmospheres hydraulic pressure. They come in sizes of 50 to 500 gallons capacity, and are painted black to differentiate them from cylinders containing compressed oxygen, which are painted red. The bottles are made to lie horizontally or stand vertically, and are provided with a spindle valve at the top. For use, a coupling or "collar" is attached to the orifice of the cylinder, and a turn of the stop-cock releases the pressure and a portion of the liquid resumes the gaseous state and escapes through the orifice.

Soluble Gunpowder*

By Dr. F. Raschig.

BLACK gunpowder is a mixture of sulphur and carbon, which consume oxygen, with saltpeter, which furnishes oxygen. In a theoretically perfect gunpowder every molecule of sulphur and of carbon would be in contact with a molecule of saltpeter, but the production of so intimate a mixture by ordinary mechanical means is economically, and even technically, impracticable. It is possible, however, to produce by chemical methods, a still more intimate mixture, in which an oxygen-consuming group of atoms is associated with an oxygen-yielding group, within the same molecule. Thus Schoenbein produced guncotton by combining the combustible carbon and hydrogen atoms of cellulose with the nitro group, containing two loosely attached oxygen atoms. The still newer explosive, nitro-glycerin is of analogous formation, and ammonium nitrate may be regarded as an explosive of the same class, as the hydrogen atoms of ammonia are associated, in the same molecule, with the oxygen atoms of nitric acid.

Ammonium nitrate is not, in itself, a very powerful explosive, because it contains much more oxygen than is needed for the combustion of its hydrogen. In order fully to develop its explosive force it must be mixed with small quantities of other combustible substances.

The ignition velocity of these modern high explosives is many times greater than that of black gunpowder, over which they possess also the very great advantage of being smokeless. It is impossible to make the particles of carbon in black powder fine enough to insure their complete combustion in the brief duration of the explosion. Hence a dense smoke is produced by unburned particles of carbon, together with the potassium carbonate and other solid products of combustion.

Although a theoretically perfect explosive mixture cannot be produced by the usual mechanical methods it is possible to obtain such a mixture by taking advantage of the solvent power of water and thus produce a homogeneous powder, intermediate in character between an ordinary mechanical mixture and a chemical compound. It is only necessary to dissolve an oxygen-consuming substance and an oxygen-yielding substance in the same water, and to evaporate the solution to dryness in conditions favorable to uniform and homogeneous deposition of the two solutes.

It is obviously impossible to obtain in this way a mixture having the composition of ordinary gunpowder, as two of the required ingredients, sulphur and carbon, are insoluble in water. There are, however, many combustible organic substances which are soluble in water, and are cheap enough to be used in place of sulphur and carbon. The most available of these substances are the sulpho-acid salts of certain coal-tar products.

In 1893 Seidler patented an explosive obtained by evaporating mixed solutions of saltpeter and of salts of naphthalin-sulphonic acid. This process appears to have been found commercially impracticable, probably for the following reasons. In the first place, the salts of naphthalin-sulphonic acid are only slightly soluble, so that the complete evaporation of the large volume of water required for their solution is a tedious and costly operation. It has been found, furthermore, that Seidler's process does not work well on a large scale. Seidler evaporates the solution to dryness, with continual stirring. In the laboratory this can be done very well, and it yields a very homogenous mixture, but on a large scale it works poorly and produces a slow-burning powder. This result is due to a phenomenon which is called "crystallization in motion." In certain conditions two substances which are usually difficult to separate can be separated very well by evaporating their mixed solutions with gentle agitation. The minute nascent crystals of the less soluble substance are brought by the agitation into contact with every part of the solution and their growth is thus promoted. In this way cane sugar can be separated from the more soluble ingredients of a syrup, and in the same way, when mixed solutions of saltpeter and a salt of naphthalin-sulphonic acid are evaporated to dryness with gentle stirring the less soluble naphthalin-sulphonic salt is first deposited in the form of crystalline grains, which subsequently become coated with saltpeter, yielding a product which is very far from homogeneous.

The danger which attends the production of Seidler's powder is an additional deterrent to its manufacture. Seidler's process is even more dangerous than the usual method of making black gunpowder, in which the ingredients are cold when they are mixed. At the close of the operation which is described, as an example, in Seidler's patent more than 200 pounds of dry explosive mixture are stirred in a vessel heated to 212 deg. Fahr.

In order to make Seidler's idea practicable it is necessary to employ a sulpho-salt differing so little from saltpeter in solubility, that both salts will be deposited simultaneously. The most suitable sulpho-salts are the sodium salts of kresol-sulphonic acid and xylenol-sulphonic acid, which can be produced easily and cheaply. The process, furthermore, must be continuous, so that no large quantity of dry and hot explosive is ever present, but each very small portion of the mixture is removed from the source of heat as soon as it is dry.

Continuous evaporators in which a film of solution is taken up by a rotating steam-heated cylinder, from which the dry product is removed by a fixed blade, are already used in various industries. This process is particularly appropriate for explosive solutions because the evaporation is so rapid that "crystallization in motion" cannot take place, the two dissolved salts being deposited almost instantly as a perfectly homogeneous mixture, and also because danger is practically eliminated by the prompt removal of the powder, as it becomes dry, from the hot cylinder.

I will now ignite some ordinary black gunpowder and also a white powder containing 65 per cent of sodium nitrate and 35 per cent of sodium kresol-sulphonate. The white powder, you see, ignites as rapidly and burns as well as the black, although the black powder contains potassium nitrate and burns much more rapidly than it would burn if it contained sodium nitrate. Hence, I regard this new white powder as a complete and satisfactory substitute for black powder, to which it is superior in safety of production, and also in cheapness, owing partly to the substitution of sodium nitrate for potassium nitrate, but chiefly to the fact that the outlay for labor, which constitutes a large part of the cost of black powder, is reduced to a minimum in the manufacture of the white powder.

It is often asserted that the era of black powder and its substitutes has passed and that high explosives will be used exclusively in the future, but this assertion is erroneous. It is true that the consumption of high explosives is steadily increasing and that their field of application is expanding, but they can never replace black powder for some purposes, especially for use in stone quarries for the separation of large blocks, suitable for building. In sandstone quarries high explosives are absolutely inadmissible, as they completely shatter the rock around the blast-hole without detaching large blocks. When the object sought is to break up and loosen the rock to a considerable distance, and not to shatter it completely around the blast hole, slow-burning explosives of the black powder type will always be preferred to high explosives.

Immense quantities of black powder are still used in salt mines, and the same condition would prevail in coal mines if the danger of explosion from fire-damp and coal dust did not compel the employment of high explosives safer than black powder.

The new white powder possesses the disadvantage of being much more hygroscopic than black powder, owing to the presence of sodium nitrate. It is not, however, more hygroscopic than the explosives containing ammonium nitrate, which are extensively employed. Hygroscopic explosives can be kept in good condition in paraffined cartridges and water-tight containers.

* Adapted from a paper read before the German Chemical Society, and published in the *Zeitschrift fuer angewandte Chemie*.

How to Make Quartz Fiber

The Finest and Strongest Suspension Known

By C. C. Hutchins

THE extremely fine thread that may be spun from quartz is an indispensible article in every laboratory. Having no elastic set, it is a most perfect suspension for galvanometer needles, electrometer needles, etc. Being perfectly round and smooth, it makes excellent cross-wires for eye-pieces. It is stronger than steel, and a good electrical insulator; in short, it is the finest and strongest fiber known.

The high prices charged by dealers for quartz fiber are not warranted by any difficulties or expense in its manufacture. The means of making it are in almost every laboratory, or are readily supplied, and the making is itself a most interesting experiment, well worth the cost.

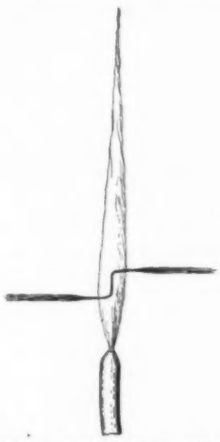
The things needed are: An oxyhydrogen blowpipe, such as may be had from a calcium light magic lantern; a pair of small gas cylinders, to be had of any dealer in stereopticon supplies; two or three yards of cheap velveteen, and some chips of transparent quartz.

It is easier to make fiber than to gather and preserve it, therefore it is well to prepare the supports for it before any is made.

To this end comes three or four pieces of board, say 6×18 inches, with the velveteen, and have similar pieces of board for covers. The cover should have narrow strips tacked across each end so as to raise them slightly. It is also a good idea to have dowel pins at two corners so that the covers may not slide off. Select some pieces of transparent quartz and break them up into grains the size of beans.

As all quartz contains water and other liquids it is impossible to work it in the blowpipe without a preliminary heating, therefore, the grains should be heated as strongly as possible either before a blast lamp or in a crucible. Even after this treatment some samples of quartz will give considerable trouble by flying to pieces in the blowpipe flame.

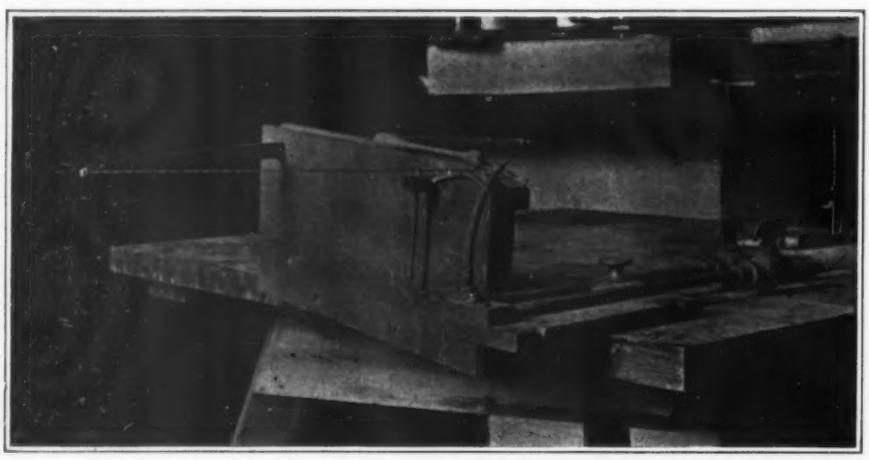
Now cut two strips of sheet iron, or heavy tin, 1×8 inches; point them at each end and fold in the middle to make two pairs of pliers for holding the quartz grains. Place the blowpipe before you on the table, so that the flame will point from you. Turn on the gas from the black cylinder, the coal gas, and ignite. The flame should be rather large, say 5 or 6 inches long, then turn on the oxygen slowly. The flame shrinks more and more until it begins to quiver. The flame is then at its hottest and further oxygen will cause it to go out with a



As the Rod Melts, the end is Drawn Toward the Tip the Other Toward the Base of the Flame.

snap. Grasp a bit of quartz in either pair of pliers and bring the two bits together in the flame. If the two do not fly to pieces they will fuse and weld, and you may draw the melted portion out into a short rod. Then add another bit of quartz and draw out, and so on until you have a rod a little smaller than the lead to an ordinary pencil and 3 or 4 inches long. The starting of this rod is the only difficult part of the whole operation, for as soon as you have a short piece, or rather two short pieces, it is better to abandon the pliers, and bending the end of one rod into a loop, lay a grain of quartz in this loop, melt, and draw out with the other rod.

Coming now to the drawing of the fiber, we have three methods according to the length and degree of fineness desired.



Catapult for Shooting Fine Quartz Fibers.

For short, thick fibers simply melt the rod in the middle and draw the two ends apart with a quick motion, at the same time removing the rod from the flame.

For long fibers make a small catapult, after the style of the ancient cross-bow, by slightly grooving the edge of a piece of board 8 inches long, passing a short bow of good elastic wood through a hole at one end, and arranging a trigger to release the bow-string from a notch at the other.

This catapult is screwed to the edge of a table, pointing at a slight angle upward, and at such a height that the flame of the blowpipe, when arranged, cuts directly across the rear of the catapult at the same height as, and at right angles to the groove. The arrow may be 3 inches long, with a cylindrical head furnished with a bead, and a flat tail. Hang up a large black cloth in range of the catapult and 10 to 20 feet distant, to serve as a target. Make a small hole in the tail of the arrow and tie in a piece of strong linen thread. Melt up a bead on the end of the quartz rod to prevent the slipping off of the thread, that may be attached to it with two or three hitches, leaving an inch or so of slack.

The flame used in drawing the fiber need not be as large and must not be as hot as that used in melting the quartz, that is, it should contain a slight excess of hydrogen, else the quartz becomes too fluid and will not spin. Heat the rod a little behind the attached thread and draw it down pretty thin; bend the bow, lay the arrow in place, bring the narrowed part of the rod into the flame and at the instant that it is about to drop off, spring the bow.

It should be noted that the nick for the bow-string should be far enough forward so that the end of the rod may rest behind it, else it will lap over when heated. The arrow flies away and sticks in the cloth, and if all has gone well somewhere between you and the arrow will be found several feet of fiber as fine as spiders' web.

If you do not find it in the air, look on the cloth.

More often the fiber produced in this manner is comparatively coarse, the finest of all being made in the following simple way: Set up the blowpipe as when making the rod. About two feet in front of it place an upright rod some four feet high and furnished with a number of wire arms twisted about it and standing out at right angles.

Draw a spot near the middle of the quartz rod down very small, then quickly melt this thin place and draw it apart by moving one part toward you, the other from you while in the flame. As the two parts separate an extremely fine thread spins from one end and is driven away into the air by the blast from the flame, and may catch on one of the wire prongs of the stand. After spinning a few threads stop, and gather in your catch. Many of the fibers made in this way are too fine to be seen and handled; but no pains should be spared to gather some as fine as possible, as the finest of them are the most generally useful.

A good way to collect them is catch them on two pieces of fine wire dipped in thin shellac. They may thus be carried and laid down upon one of the supports prepared for them. The whole operation is much less difficult than it seems, and after a little practice an hour's work will furnish all the quartz fiber that will be wanted in the ordinary laboratory in several years.

In using quartz fibers for suspensions it is well to remember that shellac and other alcoholic varnishes will not hold them. According to my experience they will slip and pull away every time unless a hot body be applied to the point of attachment to melt the varnish.

Welding By Electricity

The Most Expeditious and Satisfactory Method for General Practice

ELECTRIC welding is one of the most satisfactory of all the modern methods of welding in use. It brings a great saving in time, labor, and stock, items that mean actual value. We illustrate herewith the equipment of a plant at Cleveland, Ohio, one of the largest and best equipped welding plants in the world, operated by experts skilled in the art of electric welding.

The engineers at this plant claim that as long as there is a projecting boss or lug of the same cross-section as the part to which it is to be welded, and the material is of a weldable grade, a satisfactory weld can always be made and their experience with a variety of conditions, shapes and diameters shows that there is scarcely a thing that cannot be electrically welded to advantage. Furthermore, there are cases in which a weld cannot possibly be made by any other process as the part where the weld would be made is too short for either a forge or hammer weld, thus making it necessary to forge them from solid stock, which means expensive forging dies and an enormous waste of material.

The accompanying illustrations, Figs. 2 and 3, show the installation at Conshohocken, Pa., for producing the electric welded combination boiler and gas water heater and other electric weld products.

It is well known that welding is one of the most difficult operations in the manufacture and use of metals. When the operation is performed by hand it is always expensive and frequently inconvenient, and reliable welds are rarely obtained unless a man of considerable skill be employed.

Little progress has been made during the past 100 years in the art of welding by hand, notwithstanding the fact that reliable results are more and more needed as the manufacture of metals and alloys becomes improved and higher working stresses are demanded.

The process of welding is the operation of uniting two or more pieces of metal by heating the surfaces to be joined, and forcing them together either by hammering or other pressure, while the metal surface is in a plastic

state. A perfect weld might be defined as one in which the metal at and near the weld remains equal in strength and ductility to those parts of the metal which have not been heated.

In the ordinary process of welding two pieces of iron, the smith heats the ends in a fire until so far as he is able to judge, the temperature has become somewhat higher than the correct welding temperature. The ends are then placed together and treated with a flux (such as borax) which melts and quickly covers the heated surface, thus preventing the further access of air, and, at the same time, reducing the oxide scale already formed to a liquid state; the smith then hammers the two ends together, his aim being to force out from the surfaces in contact all the burnt iron and all the flux, and also to produce a smooth round surface.

The quality of the weld depends almost entirely on the skill which has been exercised in bringing the metal to just the right temperature and in hammering or squeezing out all the burnt metal and the flux.

The welding of brass and copper is impracticable by the ordinary methods. Copper would have to be raised to a very high temperature, as compared with iron, and is then highly oxidizable and liable to form a scale difficult to treat by the flux; it also passes quickly from the solid to the molten state and is brittle near the welding temperature: while with brass it is difficult to avoid volatilization of the zinc before the copper constituent has been raised to the necessary temperature; and further this alloy also becomes very brittle near the welding temperature.

Until recently such metals and alloys have been united by brazing or soldering; operations which require considerable skill and are expensive in the matter of solder, fluxes, heating appliances and labor charges. These metals and alloys can however readily be welded electrically and under certain conditions, there is no difficulty in making a good weld between two entirely different metals or alloys.

Welding by electricity is capable of producing such astonishing results that it has revolutionized many manufacturing operations; and although there may have been some disappointing experiences with this process, due chiefly to the injudicious selection of methods and machines for the particular work in hand, it is a fact that perfectly reliable and most satisfactory results can now be obtained not only in electrically welded iron, and some kinds of steel but also in copper, brass and many other metals and alloys. Highly skilled labor is no longer required, and the rate of production is enormously increased, the net result being that more reliable work can be turned out at a fraction of the previous cost.

Before considering the V and latest American electric welding machines it may be of interest to note the details of construction and method of operation of an English welder developed by a firm of Prescot, Lancashire, England, for the electric welding of their wires and cables.

A complete series of electric welders were specially designed for dealing with wires and rods of the smallest possible sizes up to rods of the following sizes as maximum: Iron or weldable steel is electrically welded up to 2 inches diameter, brass to 1¼ inches diameter and copper to ⅞ inch, while bars and strips of any shape or section can also be welded, provided the sectional area does not materially exceed that of the equivalent areas for rods given above.

In the use of these English electric welders at the Prescot works there is rolled considerably more than 200 tons of copper per week, the bulk of this being drawn into wire of various sizes from ⅜ inch diameter downwards, or rolled and drawn into strips of various sections for electrical purposes, and the number of welds which have to be made in the different stages of manufacture reaches an incredible figure.

In this British wire and cable works many welds are made in the iron and steel armoring for the cables, as well as in other manufacturing processes. Highly skilled labor not being demanded to operate these machines, the man, or youth can readily be employed on other work while the welder is not in use. All the machines referred to above are supplied with current by one 15 kilowatt transformer, the pressure being 100 volts at 50 alternations per second.

It is stated that in the case of iron and weldable steel an unskilled man, or youth, after a few hours' practice, produces welds far superior to those turned out by hand

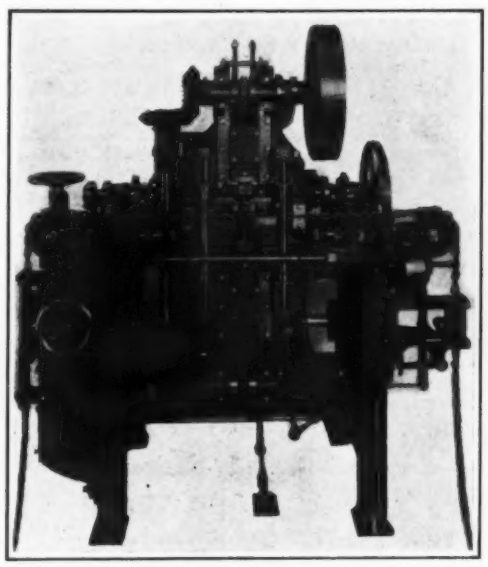


Fig. 1.—An Automatic Electric Chain Welder.

by the highly skilled smith. Thoroughly sound welds can be made in copper with the utmost ease, and it is a most important fact that brass can be welded without destroying the structure given to it by rolling or drawing, and the welds will stand all the rolling and drawing processes necessary to work the material down to the smaller sizes. The manner in which this is accomplished will be explained later.

The electrical connections and the system adopted in the construction of the Prescot welders is shown by the drawing in Fig. 4. *A* is an alternating current dynamo which can be connected by means of switches *H* and *D* to the primary coil *P* of the transformer. The secondary coil of the transformer consists of a massive single convolution *SS* terminating externally in two massive clamps *CC* which grip the two rods to be welded together. When the switches are closed the generator supplies a current of moderate strength at a pressure of say 200 volts to the primary coil *P* of the transformer. This current is transformed by electro-magnetic induction, into a current of very low voltage, but very great strength, in the secondary coil *S*, and the heavy current so produced flows across the junction of the two pieces to be welded *BB*, their ends being kept in contact under moderate pressure. The electrical resistance in the secondary circuit being practically all located at the two end surfaces, thus kept in contact, all the heat is developed at those surfaces, that is to say, just where the weld is to be made; and the resulting increase in temperature, by further increasing the electrical resistance at this point, adds to the desired effect.

A device is provided for regulating the pressure between the ends of the rods, since this pressure must be made to suit the size of the rods and the plasticity of the metal at its correct welding temperature. After a few seconds the metal begins to flow, and the rods become perfectly united, the metal bulging out slightly round the joint, and at this stage the current is cut off by the switch *D*. The joint can readily be trimmed down to the correct size by filing or by an emery wheel. One of the most important advantages attending this method of welding is, that the heat is applied only at the exact spot where the weld is required. Appliances are provided for regulating the pressure between the ends of the rods, and for cutting off the current automatically at the right moment. The conductors connected to the primary circuit are well insulated and protected and cannot come into contact with the operator; while the secondary circuit, by means of which the actual welding is performed, has such a low voltage that any part of it can be handled with impunity. There is therefore no danger of shock to the operator.

The conditions for successful welding vary with different materials. With iron or steel it is necessary to keep the temperature below the melting point to avoid injury to the mechanical properties of the metal, and consequently, considerable pressure must be exerted. In other cases the metal is allowed to actually fuse at the junction, and the pressure should be only just sufficient to force out the burnt metal the current being cut off at the moment the ends of the rods are squeezed together at the proper welding temperature. It is this forcing away of the burnt metal which enables such good results to be obtained with drawn brass rods.

In cases where suitable electrical power does not already exist, a special self-exciting alternating current generator is used which can be driven from shafting at any convenient position in the works, or by any other available source of power. This generator need not be near the welder. The size of the generator varies with the work to be done, but the largest machine likely to be required for ordinary use is one with an output of 8 kilowatts (say 13 horse-power). This is a four pole self-exciting machine, the speed being 1,500 revolutions per minute, giving 200 volts at 50 alternations per second. This generator will supply power to several welders, and of course, it must be remembered that each welder is only taking power from the generator at intervals for a few seconds at a time.

It frequently happens that electrical power is already available, and if not in a form suitable for direct use on the welder, there is used either a static transformer or a motor transformer capable of converting the current into the form required.

At the switchboard there is usually employed an ammeter, voltmeter, double pole switch and fuses, and also —in those cases where a special generator is used—a regulating resistance, for varying the voltage of the generator to suit different classes of work, this regulating resistance being connected in series with the field coils of the generator. In cases where the welding current is taken from an outside supply, the switchboard is not provided with a regulating resistance, this as a rule being unnecessary.

A feature of the English transformer used for electric welding is the method of construction, whereby use is made of the main casting of the welder to form the secondary coil of the transformer, the primary coil being inclosed therein and effectively protected. This special

Fig. 2.—Electric Welding Applied to the Manufacture of Gas Water Heater.

Fig. 3.—Electric Welders, Plate Rolls and Punches in a Pennsylvania Boiler Factory.

feature in the design is said to be one of the reasons for the exceptional efficiency and economy of this apparatus.

The clamps used in holding the material to be welded are massive in construction in order to prevent rise in temperature in the machine itself. They are shaped to suit the pieces to be welded, and are provided with means for quickly setting and removing the pieces operated on. One clamp is fixed in position and the other movable, the latter working upon a sliding bed. A water cooling arrangement is often added when the nature and amount of the work is such that the clamps cannot otherwise be kept cool; though this very rarely happens, and the device is only necessary for very large work.

On the Prescot welder the operating lever possesses some entirely new features. Its function is to enable the position of the movable clamp to be varied and to adjust the pressure on the ends of the pieces to be welded. In conjunction with the lever there is rack and pawl, which enables the movable clamp to be set in any desired position, thus obviating the necessity of finding and using distance pieces of various sizes. The lever is also provided with a regulating device, which enables the pressure on the welding surface to be adjusted.

There is an automatic switch placed in a convenient position on the welder by means of which the circuit of the primary coil can be closed at the instant current is required, thus preventing any waste of energy while the machine is not in use. This switch is automatically released and the circuit broken at the critical moment. The adjustable steel pin carried by the moving clamp strikes an arm and releases the switch. The switch is of such a design that it is impossible for it to stick or fail to be automatically released.

The smallest Prescot electric welder is suitable for welding copper, brass, iron and weldable steel wires, from 0.020 inch diameter to 0.030 inch diameter and the maximum power required during welding operation is less than 1/10 horse-power lasting one second for one weld. The cost of current is 2 cents per kilowatt, less than 2 cents for 1,000 welds. The machine weighs 40 pounds and its approximate overall dimensions are 17 inches by 7 inches by 12 inches high.

For the electric welder suitable for welding wires from 0.030 inches diameter to 0.64 inches diameter the maximum power required during welding operation is less than ½ horse-power, lasting two seconds for one weld, and the cost of current at 2 cents per unit is less than 2 cents for 1,000 welds. This machine has a weight of 56 pounds and is 17 inches long, 7 inches wide and 12 inches high.

The electric welder of very great range, suitable for welding iron or weldable steel wires from 0.005 inch to 0.25 inch diameter has an automatic cut-off so arranged that it cannot be closed unless the pawl which keeps the jaws apart is removed. It is therefore impossible to accidentally burn the material which is to be welded. Friction is reduced to a minimum by means of a ball bearings, and consequently the machine is eminently suitable for metals otherwise difficult to weld, such as gold, silver, nickel and German silver.

There are scales provided so that the cut-off, the distance between jaws, and the spring pressure required for various materials and conditions can be readily adjusted, and the readings may be recorded for future reference. The transformer is wound in steps, and is controlled by a four-way switch, thus permitting the use of several secondary voltages, as required for different materials.

For welding the mild steel tapes used for armoring electric cables a machine operated by a foot lever and a hand screw was designed to take tapes from ½ inch to 3 inches wide, and from 0.015 inch to 0.0625 inch thick, the maximum power required during welding operation being about 8 horse-power lasting 30 seconds for one weld. This electric welder weighs 534 pounds.

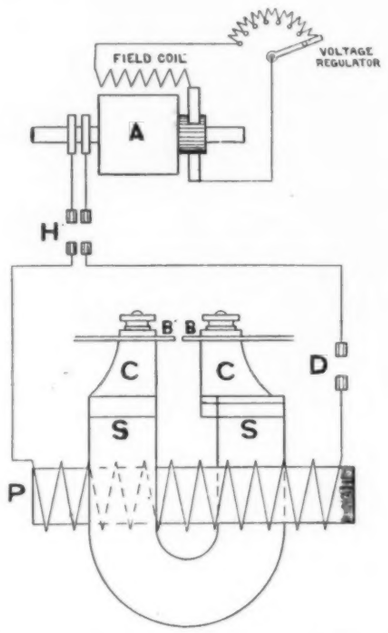


Fig. 4.—Connections of the Prescot Electric Welder.

An electric welder suitable for welding copper and brass from 375 inches diameter to 1 inch diameter, or iron and weldable steel from 500 inches to 2 inches diameter takes maximum power during welding operation of about 65 horse-power, lasting ninety seconds for one weld and has a weight of 4,150 pounds.

The English automatic chain welder developed at Prescot for automatically welding chain links performs this operation with a minimum of labor and power, independently of the skill and judgment of the operator. The material is first made into unwelded chain on another machine.

The English electric automatic chain welder is belt driven, and is provided with three shafts, one driven continuously by a pulley as long as the machine is in operation, while the other two make periodically one revolution only. The unwelded chain is fed through the left-hand channel to the welding point, where each link in turn is gripped by the upsetting levers and the contact pieces.

At this juncture the primary circuit is closed and a clutch is thrown out of gear to bring the cam shafts to rest. The current when passing from one contact piece to the other, by means of the interposed portion of chain, heats and softens that part of the link which is to be welded. Weights suspended on a toggle lever then come into action and make the weld by upsetting the link. At the same tine the clutch puts into motion the cam shafts, which switch off the current and close the swaging levers on the link while it is still at welding heat and still under the pressure of the upsetting toggle, thus insuring a thoroughly sound weld.

The chain is now fed along, and the next link is brought to the welding point, where it is gripped and welded; and so the cycle of operations is repeated as long as the chain is fed into the machine. The swaging process leaves at the weld a thin fin, which is removed by a shearing device.

Our frontispiece shows an American electric welder of another type at work, welding a heavy ring 3x⅝ inches, 70,000 watts being used for 50 seconds.

A five-ton jack is operated by the lever to push the ends of the ring together when they reach a welding heat.

Water circulation is maintained in the clamps to keep them as cool as possible. The foot opens and closes the circuit while the clamps are operated by hand.

The accompanying illustration Fig. 1 shows an automatic electric chain welder. Another special machine is an automatic electric welder for foot bands used on woodenware. In the operating of this machine the opening and closing of the fans; the movement of the clamps together when the joint comes to a welding heat and closing of the circuit are all automatic. The boy has only to put in the band and take it out.

The Correlation Between Sunspots and the Weather*

The Evidence of Periodic and Abnormal Occurrences

By Prof. A. Gockel

DAILY experience teaches that the state of the atmosphere depends, directly or indirectly, upon the condition of the sun. Practically, the temperature that prevails at the earth's surface depends solely upon the difference between the rates at which heat is received from the sun and lost by radiation, as the meteorological effect of the internal heat of the earth is insignificant. Hence it is not surprising that the younger Herschel, in 1801, conjectured that sun spots must exert an influence upon crops, although the periodicity of sun spots had not yet been recognized.

In 1843 Schwabe, after seventeen years of observation, announced that the number of sun spots varies periodically. Since then almost every phenomenon connected with the weather has been attributed to sun spots, but all of these speculations, many of which are very improbable, have hitherto remained unproven. The electrical state of the earth and the atmosphere, the aurora borealis and the variations of terrestrial magnetism, are the only phenomena which exhibit periodic fluctuations unquestionably correlated with the number of sun spots.

On the other hand, no observed change in temperature, wind or other meteorological or climatic factor has been connected, with certainty, with variations in solar activity.

The problem is a very difficult one. If, for example, we admit that the solar radiation increases with the number of sun spots it is evident that this increase will be felt most intensely in the tropics. But the resultant elevation of temperature will cause an increased production of water vapor and of clouds, which will lower the temperature in the temperate zones. The factors that affect the distribution of atmospheric temperatures and pressures over the surface of the globe are so numerous and so diverse that it has not yet been found possible to deduce accurate weather forecasts for any locality even from recent observations of the weather in the surrounding region.

This example illustrates the difficulty of detecting the influence exerted upon local weather conditions by variations in solar activity. Furthermore, it is so difficult to measure the solar radiation that the coincidence of its fluctuations with those of sun spot activity is still the subject of animated controversy.

Hence we have three questions to answer:

1. Is it possible to demonstrate the occurrence of variations in the intensity of solar radiation?

2. Do these variations coincide with observed variations in the number and size of sun spots?

3. What relations exist between variations in solar activity and changes of weather at a given place?

We will discuss the first and second questions together. The difficulty encountered in measuring the solar radiation is due to the fact that this radiation is partially absorbed by the atmosphere. The proportion which is absorbed depends on atmospheric conditions. It is obvious that the absorption will be greater when the sky is covered with clouds than when it is clear, but much of the radiation may be intercepted by invisible masses of water vapor in the upper atmosphere. The variation in the solar radiation which reaches the earth's surface is due chiefly to variation in atmospheric absorption. The lower strata of the atmosphere have more absorbing power than the upper strata, because they are denser and more laden with water vapor and dust. Hence we can partly eliminate the fluctuations in atmospheric absorption by making our observations on lofty mountain peaks. In Europe, experiments have been conducted on Mont Blanc, and on a larger scale on Mont Rose (elevation 14,400 feet) which is a little lower, but more accessible, and is the site of a well-equipped observatory. The American experiments have been made principally on Mount Wilson (5,900 feet) and Mount Whitney (14,400 feet), in southern California. From measurements made simultaneously at two neighboring stations which differ considerably in altitude it is possible to calculate the amount of radiation absorbed by the air situated between those altitudes, and thence to deduce, approximately, the absorption in the higher and inaccessible strata. In this way the intensity of solar radiation at the upper limit of the atmosphere can be computed, approximately.

All of these experiments, with the exception of one which will be discussed presently, indicate that the solar constant, i. e., the quantity of solar heat received per minute by a unit of surface normal to the rays at the boundary of the atmosphere, is really constant, within the limit of precision of our instruments. No change in the solar constant that can be attributed to sun spot variation can be detected. This result might have been foreseen, for the spots at their maximum epochs cover but a small part of the sun's surface. Comparative measurements show that the spots emit nearly or quite as much heat as other parts. It has not even been proved conclusively that the spots are cooler than their environment, although Hale and Adams infer a lower temperature from the [illegible] studies of sun spot spectra which they

* Abridged from a French translation, published in *Le Monde*, of Prof. Gockel's article in *Natur und Kultur*.

the perfect special apparatus of the Yerkes observatory.

In any case, the spots, at their maximum epochs, cannot diminish the solar radiation by more than 0.1 per cent, and our instruments cannot detect so small a difference. Moreover, the hot protuberances increase with the spots and produce a compensatory effect.

Langley, who measured the intensity of solar radiation in every part of the spectrum with his sensitive and accurate bolometer, thought that he had detected a periodic variation, but his results have been disputed.

Another American astronomer, Humphrey, thought he had proved, despite the approximate invariability of the solar constant, that the temperature of the earth varies with the solar activity. He reasoned as follows: Although the total energy emitted by the sun remains constant, its distribution through the spectrum may vary according to the condition of the solar atmosphere.

The fact that the luminous intensity of the sun diminishes from the center to the periphery, and that the diminution is greatest in the violet and ultra-violet regions, proves that the solar atmosphere absorbs some of the radiation and that the absorption increases as the wave length increases. The ultra-violet absorption probably increases with the number of sun spots, for in our own atmosphere this absorption is increased by any disturbance. As ultra-violet rays convert oxygen into ozone, it is probable that large quantities of ozone are formed in the higher strata of our atmosphere, where the greatest absorption of ultra-violet rays takes place. But ozone, though quite transparent to the luminous solar rays, strongly absorb the non-luminous radiation from the earth. Hence an increase in the quantity of ozone in the atmosphere would diminish terrestrial radiation and consequently increase the temperature. To the production of ozone in the polar regions by the electric discharges of the aurora Humphrey attributes the following remarkable phenomenon observed by the German expedition to East Africa. At the equator the temperature of the upper strata of the atmosphere is about 15 degrees lower than that of strata of the same altitude in the temperate and frigid zones. Sun spot maxima are accompanied by maximum auroral discharges, which increase the quantity of ozone in the atmosphere. But the diminution in ultra-violet radiation caused by the sun spots would, according to Humphrey, predominate to such an extent that the final result would be a diminution in the production of ozone, an increase in terrestrial radiation and a lowering of temperature.

Abbot and Fowle claim to have proved, by a study of the temperatures recorded at numerous stations during many years, that the mean temperature at the earth's surface is lowered about 1 deg. Cent. at the epochs of sun spot maxima.

But a lowering of temperature at one station is usually accompanied by an elevation of temperature at other stations. Hence this demonstration cannot be conclusive unless the stations chosen are distributed uniformly over the globe, a condition that cannot be satisfied while the oceans, the polar regions and other vast areas are entirely destitute of meteorological stations. For this reason the conclusions of Abbot and Fowle have not been generally accepted.

The most serious objection to Humphrey's reasoning, as he admits, is the frequent occurence of variations in the violet and ultra-violet radiation which cannot be correlated with variations in sun spot activity.

Let us now consider the third and most important question. We find a great diversity of opinion concerning the relations existing between sun spots and the weather. Newcomb concludes, from the records of a number of tropical and temperate stations, that the mean annual temperature of the earth, like the number of sun spots, has an eleven-year period of variation, with a difference of 0.26 deg. Cent. between the hottest and the coldest years. Koppen deduces a difference twice as great from records of tropical stations between the years 1827 and 1877. Other meteorologists, however, deny the existence of such a period, and attempts to establish a correlation between sun spots and exceptionally hot and cold seasons have yielded contradictory results.

On the other hand, the existence of a correlation between sun spots and rain appears to be established. Hellmann, in his treatise on the rains of northern Germany, asserts that the maximum rainfall coincides with the sun spot minimum and the year preceding, but that a secondary maximum of rainfall occurs in the year of maximum sun spot development. This conclusion is drawn from the records of twenty-one stations for the years 1851 to 1900. Hergyfoky deduces the same result from observations made during fifty years at Vienna, Milan and a dozen Hungarian stations.

This correlation between rainfall and sun spots is in agreement with Humphrey's theory. I have shown elsewhere that the formation of rain is facilitated by the presence of nuclei of condensation. In the upper strata of the atmosphere there is very little dust, and the nuclei of condensation consist chiefly of ions, or electrified molecules, produced by the agency of ultra-violet rays. According to Humphrey the ultra-violet radiation is greatly diminished at the epochs of sun spot maxima. At such times, therefore, the rainfall is likewise diminished and the water vapor remains suspended in the atmosphere. As this vapor is transparent to the luminous rays of the sun, but absorbs much of the non-luminous radiation of the earth, the increase in the amount of vapor should produce an elevation of temperature—an inference which Humphrey does not make.

It appears, furthermore, from the observations made by Meldrum in Mauritius and by Poey in the Antilles, that the frequency of cyclones increases with the number of sun spots.

Klein claims to have found a correlation between solar activity and the frequency of cirrus clouds.

The phenomena of terrestrial magnetism exhibit an unquestionable correlation with the sun spot period. In addition to the small annual and diurnal variations in the magnetic declination, which may be regarded as direct effects of solar heat or ionization of the atmosphere there are occasional greater perturbations which continue for hours, and which are most frequent and violent at the epochs of maximum sun spot activity. These magnetic storms, in which the deviation of the needle may attain one degree, are often observed almost simultaneously over a large part of the earth's surface. They occur usually when conspicuous groups of sun spots directly face the earth; and Ricco asserts that the magnetic influence of a sun spot is propagated with a velocity of 1,000 kilometers per second, so that it reaches the earth in 42½ hours.

Hale, at the Yerkes observatory, has demonstrated the existence, in the sun, of magnetic fields of considerable but variable intensity. This discovery was made by utilizing the peculiar effect of magnetism upon luminous vibrations which was suspected by Faraday, but first observed by Zeeman.

In view of the close correlation existing between auroras and terrestrial magnetism the former might be expected to exhibit a dependence upon solar activity. As a matter of fact, this dependence was demonstrated before the sun's influence upon the magnetic needle was proved.

The effect which solar radiation exerts upon terrestrial magnetism is unquestionably indirect and is produced by ironization in the upper atmosphere. If this ionization varies with solar activity, rainfall, temperature and other meteorological phenomena may reasonably be expected to vary concurrently. Hence attempts to show a correlation between sun spots and weather appear promising, though they have been successful, hitherto, only in isolated cases. Amateur observers may find here a vast field for researches which involve little expense, as the astronomical and meteorological elements of the problem are easily accessible, and records of sun spots are published in popular scientific journals. The observer should, however, be endowed with a critical faculty which will prevent the discovery of imaginary correlations based on preconceived opinions.

The correlation which has been supposed to exist between sun spots and earthquakes appears very improbable.

The search for a correlation between sun spots and weather has generally been conducted by looking for analogous periodic variations in the two phenomena.

Another possible method consists in seeking abnormal weather conditions occurring simultaneously with abnormal solar activity. Krebs, a firm believer in the influence of sun spots on terrestrial phenomena, has long published in *Natur und Kultur* regular records of extraordinary occurrences in the atmosphere and the interior of the earth which he attributes to sun spot activity. Although these coincidences are very interesting they have not yet converted me to belief in the author's theories, because it is not proved that similar phenomena occur only when spots appear on the sun. Earthquakes, volcanic eruptions, tempests and heavy rains are so frequent that one or the other is reported almost weekly from some part of the globe. I have already remarked that temperature changes in one region are often accompanied by inverse changes in another. In addressing the Congress of Naturalists at Stuttgart, Krebs attributed to sun spots the wet weather which had recently prevailed throughout northern Germany. During the same period western Switzerland suffered from a very severe drought, and very little rain fell in the southwestern part of Germany.

Surface Combustion*

A Radical Innovation in Industrial Heating Practice

By Prof. W. A. Bone, F. R. S.

THE influence of hot surfaces, such as that of metallic platinum, in promoting combustion at low temperatures occupied during the first third of the last century the attention of Sir Humphrey Davy, William Henry Thomas Graham, Faraday, and de la Rive in England, and in France of Dulong and Thénard, and also of Döbereiner, but not one of these distinguished men succeeded in finding a satisfactory explanation of the phenomenon, and the Döbereiner lamp constituted the only practical outcome of the whole investigation. A long controversy on the subject between Faraday and de la Rive terminated in 1836, and interest in the subject then dropped.

Indeed, while the power of platinum in inducing combustion was recognized as a scientific anomaly, in technical circles the belief prevailed that contact between gases and hot surfaces should be avoided. This conviction was mainly due to the work of Mr. Frederick Siemens, who was the first to recognize the importance of radiation in furnace operations, but was under the erroneous impression that contact with hot surfaces would retard combustion by lowering the temperature of dissociation. My own connection with the subject arose during the course of an investigation into the mechanism of the combustion of hydrocarbons at low temperatures, which was carried out at Owens College in conjunction with Mr. R. V. Wheeler. The subject proved so attractive that it was extended into an inquiry as to the behavior of a variety of hot surfaces in promoting combination at temperatures below the ignition point. As a result of these and subsequent researches it is possible to state definitely that all hot surfaces accelerated combustion, but the extent of their action is dependent on the temperature and character of the surface, and was perhaps connected with corpuscular discharges.

Combustion may proceed "homogeneously," that is to say, equally throughout the system as a whole; or "heterogeneously," that is to say, in layers immediately in contact with an incandescent surface. The latter is a far more rapid process than homogeneous combustion, but the activity of a surface can, it is found, be accelerated or retarded at will by means of previous special treatment. Thus the combination of hydrogen and oxygen or of carbon monoxide and oxygen, in contact with a non-oxidizable metal, can be greatly stimulated by previously putting the metal into contact with the combustible gas, or, conversely, it may be diminished by letting the surface have previous contact with oxygen. There is evidence that surface combustion is dependent on a prior absorption or condensation of the combustible gas, and perhaps also of the oxygen, but to what exent this occurs is not yet clear. Nevertheless, in some way or other the condensed gas becomes "activated," probably ionized, and this activity increases according to the compound interest law. There are, moreover, certain other important differences between homogeneous and surface combustion; thus the presence of water vapor accelerates the homogeneous combustion of carbon monoxide, but it retards the surface combustion of this gas if the surface is that of fire-clay. Again, in ordinary combustion, methane has a greater affinity for oxygen than hydrogen has, but the presence of a hot surface reverses the position of the two gases in this regard. This is a very remarkable fact, and affords proof that surface combustion was a real phenomenon.

As stated, all hot solids accelerate combustion, and this acceleration is the greater the higher the temperature, becoming especially marked when the surface is incandescent. At low temperatures there are great dif-

* The report here given is adapted from *Engineering*.

Fig. 1.—A Simple Form of Heater.

ferences in the efficiency of different surfaces, but this difference diminishes much at high temperatures.

If an explosive mixture is forced through a porous, refractory, and hot material, the rate of combination is accelerated at the surface in contact with the escaping gases. There is no flame, and this method of causing the gases to combine seems destined to greatly increase the efficiency of industrial heating operations. I had satisfied myself that this was the case in 1897, and since then I have, in conjunction with Mr. McCourt, put the system into practical operation. The methods developed are based upon a number of considerations which might be specified as follows:

In the first place, all surfaces, it is found, act equally well, the combustion is flameless, the temperatures attained are higher than in ordinary combustion, and there is a great economy of fuel. Secondly, in considering this process it is necessary to think in molecular dimensions, discharging from the mind all ordinary measures of time and space. Thus, when the combination is spoken of as occurring within the pores of the material, these pores must be understood as being of molecular dimensions, since a body may be very dense and yet quite porous in the sense in which the word is here used. Only vitreous substances, such as glass, can be considered as non-porous from this standpoint, and even glass becomes porous when devitrified. Further, the incandescent solid must not be considered a mere idler or looker-on at the crowd of reacting molecules; actually it galvanizes into life the dormant affinities, with the result that the stately minuet of ordinary flame combustion gives place to the wild intoxication of the Venusberg. This fact can no longer be disputed. At the meeting of the British Association in 1910, Sir J. J. Thomson insisted that combustion was not a matter in which molecules and atoms alone were concerned, but that the electrons played a very important part; and he then suggested that the effect of hot surfaces in promoting combustion might be due to the emission of charged particles from such surfaces. These particles were given out at high velocities from incandescent surfaces, and the effect of the latter might therefore be due to the formation of an electrified layer of gas in which chemical changes proceeded with extraordinary velocity.

Leaving this theoretical aspect of the question, and passing on to describe some of the more important features of the two systems of effecting surface combustion which have been developed at the works of Messrs. Wilson and Mathiesons, Limited, of Leeds, it may be

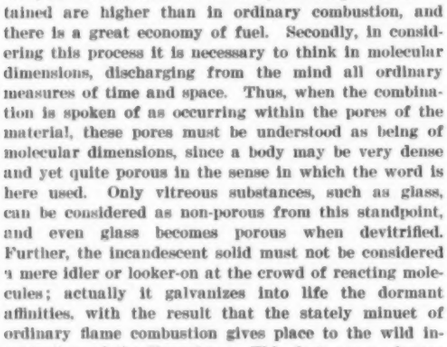


Fig. 6.—Experimental Boiler.

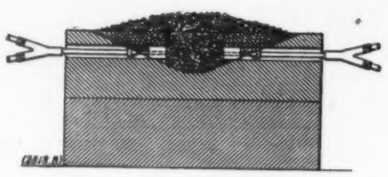


Fig. 2.—Heating a Smith's Hearth.

said that the distinguishing feature of this method of heating is that an explosive mixture of gas and air is burned without flame in contact with a granular incandescent solid, and in this way a large proportion of the potential energy of the gas is converted into the radiant form. The rate of combustion is greatly accelerated, and the heat developed can be concentrated just where required. Perfect combustion is attained with a minimum of air and very high temperatures can be reached without the use of regenerators, while the radiant energy liberated is, moreover, transmitted very

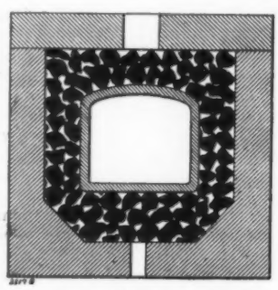


Fig. 3.—Muffle Furnace.

rapidly to any object exposed to it. In this way a new system of heating has been developed, which is very economical of fuel, as well as very easy of application.

One form of heater is a plate of fireclay, which (see Fig. 1) forms the front side of a flat cast-iron chamber, to which air and gas are admitted under pressure. The plate of fireclay is porous, and easily traversed by the air and the gas. In starting up the heater, gas only is turned on in the first instance, and ignited on the front face of the fireclay. Air is next turned on, and the flame first becomes colorless, and,

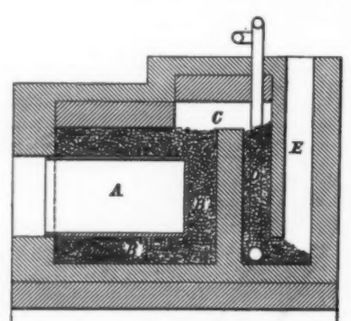


Fig. 5.—Large Muffle Furnace.

as the surface heats up, finally disappears from the face of the fireclay, which grows brighter, and glows vividly under the surface combustion which supervenes. The pressure required in the feeding chamber is ⅛ inch of water. Where a supply of air under pressure is not available, the apparatus may then be worked with an injector, the gas drawing in the air necessary for its own combustion, but to do this the gas has to be supplied at a pressure of 1 pound to 2 pounds per square inch. The layer in which the combustion proceeded is very thin, extending not more than ⅛ inch to ¼ inch below the surface. There is no development of heat elsewhere.

With the air and gas properly adjusted the combustion is perfect, no gas escaping unburned. The temperature can, moreover, be varied by altering the rate of feed, and the response to this change is instantaneous, there being no temperature lag. The highest temperature attained depends, of course, on the conditions of working. With free radiation and with coal gas as the fuel, temperatures of from 1,500 deg. Fahr. to 1,600 deg. Fahr. are readily reached. The diaphragm will work with any gas; coal gas, water gas, natural gas, and Mond gas being all well suited to its operation.

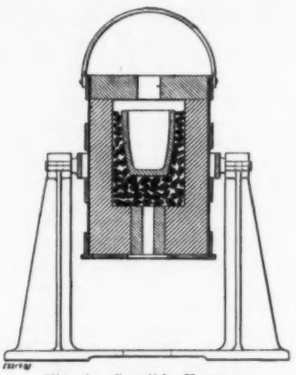


Fig. 4.—Crucible Furnace.

Exhaustive experiments have been made at Armley with one 4 square feet in area, and has enabled us to vouch for its durability in prolonged use.

It is important to note that the incandescence is in no way dependent on the outer atmosphere. Once started, a diaphragm will work as well in an atmosphere of carbon dioxide as in air.

The fact that the diaphragm can be operated in any position makes it possible to evaporate liquids by a supply of heat from above. Thus a solution of sodium silicate can be readily evaporated by one of these diaphragms, a feat very difficult to accomplish with flame-contact heating. With a top heat supplied by the diaphragm the sodium silicate which separates collects on the top of the solution and can be skimmed off. The method is also applicable to completing the evaporation of other highly concentrated liquids.

Another application of the method is that to the heating of a smith's hearth, as shown in Fig. 2, or to the heating of muffles and crucibles, as illustrated in Figs. 3 and 4. Here the interspace between the walls of the furnace and the muffle, or of the crucible, is filled with fragments of porous refractory material. After having heated up this by means of gas, supplied alone, air is turned on, forming an explosive mixture, which, however, is fed in too fast for back-firing to occur. Surface combustion then arises, there being no production of flame, but the combustion is so rapid that very high temperatures are attained.

In another method of applying the same principle the refractory material is placed in tubes immersed in the material to be heated. This method is applicable to water-heating, steam-raising, and to the melting of metals having a fusing point below 700 deg. Cent.; but for the highest temperatures the plan first described is adopted. With this the upper limit of temperature attainable is, in the case of rich fuels such as coal gas, fixed by the nature of the refractory material available. A No. 39 Seger cone has, for example, been melted in a crucible furnace of this kind, the temperature being 1,880 deg. Cent. Platinum is easily melted, and an alundum crucible consisting almost wholly of pure alumina has been melted down. At one stage of the experiments, indeed, difficulty had been experienced in obtaining material which would withstand the temperatures attained, but this has been overcome, and muffles can now be run steadily at a temperature of 1,500 deg. Cent.

The bed used must, of course, not be such that it will flux either the crucible or the furnace walls. With coal gas as the fuel, magnesia is now used for the packing, or else a neutral refractory material is specially prepared to meet the requirements.

In starting up one of these furnaces, the gas is first turned and lighted, and then the air supply admitted.

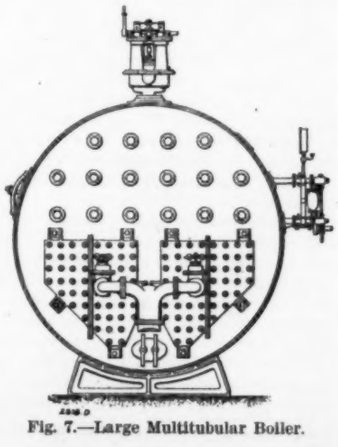


Fig. 7.—Large Multitubular Boiler.

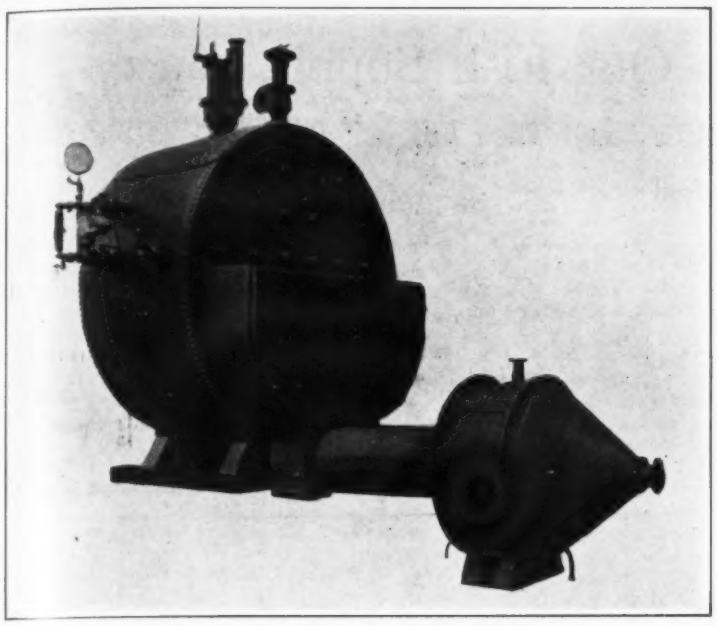


Fig. 8.—General View of the Boiler Tester.

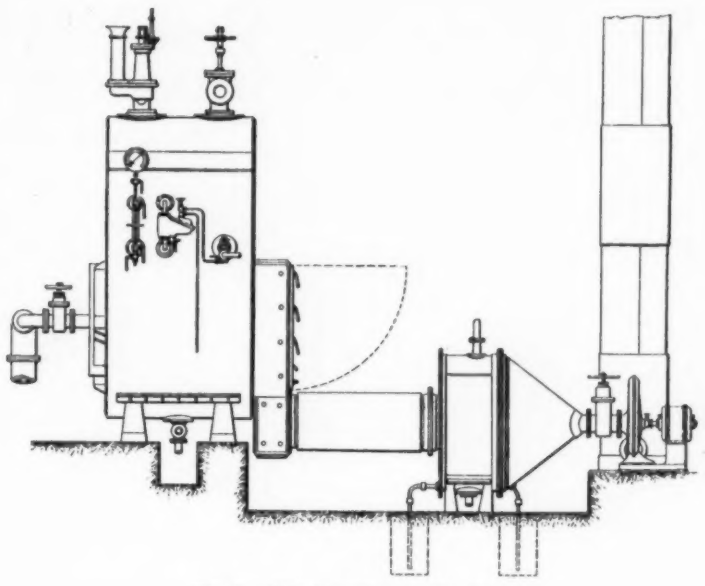


Fig. 9.—Side Elevation of the Boiler.

This causes the flame to strike back, heating the refractory packing to incandescence. When this condition is reached, the flame disappears entirely, being replaced by surface combustion. The maximum temperature attained depends on the conditions of working. With coal gas, water gas, or natural gas a temperature of 2,000 deg. Cent. can be reached without the use of regenerators, and with Mond gas in the same conditions a temperature of 1,500 deg. Cent. is attained. By providing for a little recuperation of the waste heat in warming up the air, this limit can, however, be exceeded.

With a small muffle furnace heating a muffle measuring 9½ inches by 5¼ inches by 3¼ inches, the results recorded in the accompanying table were obtained.

Results of Test on a Muffle Furnace.
Dimensions of Muffle, 9½ × 5¼ × 3¼.

Temperature in Middle of Muffle.		Gas Consumption to Maintain Temperature Constant.	Temperature of Products.	
deg. C.	deg. F.	cub. ft./hr. at 15 deg. C.	deg. C.	deg. F.
815	1449	21.0	540	1004
1004	1840	35.3	645	1195
1226	2301	58.0	870	1598
1424	2596	79.0	1085	1985

Mean net cal. value of gas = 540 B.Th.U. per cubic foot at 15 deg. Cent.

The most noteworthy point is the relatively low temperature of the escaping products of combustion. This is in every case considerably lower than that of the muffle. Thus with a temperature of 1,424 degrees at the middle of the muffle, the temperature of the products of combustion was some 300 deg. Cent. less. There was no appearance of flame at the vent even with the highest temperatures. In some comparative experiments with a good specimen of the ordinary type of muffle furnace, the maintenance of a temperature of 1,057 deg. Cent. required the consumption of 105 cubic feet per hour of the same gas. With surface combustion a consumption of 43 cubic feet per hour would have sufficed. In a series of competitive trials made in the United States with American gas-fired furnaces, the flameless combustion system required only half the gas to maintain a given temperature. A very important application of the principle to a large muffle furnace is illustrated in Fig. 5. The muffle in question measures 8 feet by 3 feet by 3 feet internal dimensions. The gas and air are fed in at the front to a bed of granular material. On escaping from the top of the furnace the products of combustion are led down through a second bed of refractory fragments, embedded in which is the pipe furnishing the supply of air, which is thus preheated to a temperature of 300 deg. to 500 deg. Cent. This results in a saving of 20 to 25 per cent of the already low gas consumption. Thus, if a surface-combustion furnace without this regenerator requires 50 cubic feet of gas per hour, with the regenerator in use 37 cubic feet to 40 cubic feet of gas would suffice. Further, this regenerator makes it possible to reach temperatures with "poor" gas which are otherwise only attainable with gas of high calorific value.

An important adaptation of the system is to boiler firing. Gas-fired boilers have hitherto been far from satisfactory. The efficiency of a good water-tube boiler thus fired does not exceed 55 per cent or so, and in some experiments made with Lancashire boilers, similarly operated, the thermal efficiency did not exceed 60 per cent, although economizers were fitted. A small experimental boiler, arranged to work with surface combustion, is illustrated in Fig. 6. This is a cylindrical boiler, 3 feet in diameter by 3 feet long, traversed by 10 horizontal tubes, 3 inches in diameter. These tubes are fitted at the inlet ends with a plug of fireclay as indicated, this plug having a ¾-inch hole through its center, through which the explosive mixture is forced at a speed which prohibits the possibility of back-firing. The remainder of the tubes is packed with refractory material, on which the surface combustion is effected. The air supply is very little in excess of the theoretical requirements, but the combustion is absolutely completed within a distance of about 6 inches from the point of entry. The remainder of the packing then serves to baffle the flow. Though the temperature of the material in the zone of combustion is very high, the boiler tubes there never attain a red heat. The supply of gas to the tubes is at the rate of 100 cubic feet of coal gas per hour, or an equivalent amount of a power gas. A ten-tube boiler, therefore, takes 1,000 cubic feet of gas per hour and 5,000 to 6,000 cubic feet of air. The temperature of the escaping gases is never more than some 70 deg. Cent. above the temperature of the water in the boiler, and this is further reduced by passing them through a feed-heater consisting of water-tubes immersed in a bed of refractory material. From this the products of combustion escaped at a temperature of less than 100 deg. Cent.

On a test of this boiler the air and gas pressure was, he stated, 173 inches water-gage, the drop of pressure being about 15 inches in the boiler and 2 inches in the feed-heater. The steam pressure was 100 pounds per square inch, corresponding to a temperature of 168 deg. Cent. The products of combustion left the boiler at a temperature of 230 deg. Cent., and the feed-heater at a temperature of 95 deg. Cent. The total gas supply was 996 cubic feet per hour, the calorific value being 562 British thermal units per cubic foot, so that 559,800 British thermal units were supplied per hour. The actual evaporation was 450.3 pounds per hour, equivalent to 550 pounds evaporated from and at 212 deg. Fahr. The heat transferred to the water was thus 527,800 British thermal units, so that the efficiency was 0.943. The carbon dioxide in the escaping gases was 10.6, as against a theoretical value of 11, and the free oxygen was only 1.6 per cent. The rate of evaporation was 21.6 pounds per square foot, or double that of a locomotive.

Since last November a 110-tube boiler has been at work with coke-oven gas at the Skinningrove Iron Works, Cleveland. The boiler was built to the designs of Mr. Michael Longridge, by Messrs. Richardsons, Westgarth & Co., Limited. This boiler is illustrated in Figs. 7 to 9. The drum is 10 feet in diameter and 4 feet long from back to front. It is traversed by 110 tubes 3 inches in diameter, packed, as already explained, with fragments of firebrick. The draught required is supplied by a suction fan, behind the feed-heater, giving a 20-inch water-gage. On test the mean evaporation was 20 pounds per square foot, but of this 70 per cent was effected in the first part of the length of the tubes, and 22 per cent over the next third. This steep temperature gradient along the tubes promotes circulation. Experience has further shown that scale would not adhere to the tubes. Once the thickness becomes about 1/32 inch, it scales off, falling to the bottom of the boiler.

Another application of the system is to the melting of readily fusible metals. One of the London newspapers requires to keep 20 tons of type metal molten for 16 hours out of the 24. Coal-firing is inconvenient for this purpose, and gas-firing had hitherto been costly. The apparatus they proposed to use is illustrated in Fig. 10. It consists of an iron tank lagged outside with asbestos, while inside is a 3-inch tube stopped at the bottom with a fireclay plug, on which rests the column of refractory material. A ¾-inch hole in the plug admits the supply of gas and air, which is fed in through the down tube on the right. In a test of the apparatus lead was melted at the rate of 1,176 pounds per hour, the gas consumption being 100 cubic feet. The efficiency worked out at 0.686 per cent. The

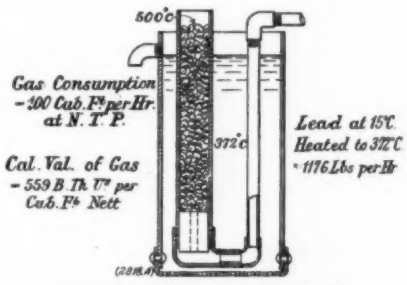


Fig. 10.—Melting Fusible Metals.

gas left at only 130 degrees above the temperature of the lead, and if it were assumed that the temperature of the latter was a limit to that of the escaping gases, the efficiency was really greater than was represented by 0.686 per cent, being actually about 80 per cent of what was theoretically possible.

Lectures on the Smoke Problem

We read in the *Journal of Industrial and Engineering Chemistry* that the Department of Industrial Research of the University of Pittsburgh has been provided by a Pittsburgh business man with funds for a thorough investigation of the smoke nuisance. This investigation is being conducted by a staff of twenty-five specialists. These men are studying the effect of smoke and soot on the atmosphere, on the weather, on plant life, on buildings, and on the public health; the economic damage done by smoke and soot; the mechanical devices for preventing or abating smoke; the chemistry and physics of smoke and soot; the laws concerning the smoke nuisance; and the history of the subject as a whole.

Recognizing the interest in the smoke problem manifested by a large number of American cities, and in response to inquiries that have been made, the department announces that the members of its staff are prepared to lecture on the following phases of this problem: "The Smoke Nuisance" (a general presentation of the main phases of the subject); "Smoke and the Public Health;" "Smoke and the Cost of Living;" "Smoke and Plant Life;" "Methods and Means of Smoke Abatement;" "The Effect of Smoke on Buildings and Building Materials;" "The Psychology of Smoke;" "The Smoke Nuisance and the Housekeeper." These lectures will be given any place east of the Mississippi, provided the expenses of the lecturer are assumed. For further particulars apply to Dr. R. C. Benner, Department of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

The Preservation of Our Fish Supply

The Banks on Our East Coast and Their Origin

By George Carroll Curtis

THOUGH recent disaster to the greatest ship by collision with ice has directed public attention to the presence of icebergs off our Atlantic coast, few realize how great a part ice has played in these regions during the past, or know how remarkably the configuration of our northeastern shoreline has been altered by glacial forces.

Icebergs themselves have played a comparatively minor part in these changes by dropping over the bottom of the sea the land debris carried frozen in their masses. The bergs, however, are small manifestations broken from the great continental glacier now melted back to Greenland, but which in earlier times was so extended that its terminal iceberg-breeding foot lay in the vicinities of New York and Boston.

While lately associated with disaster, in the past the ice has acted as a very powerful constructive agency, and is to be credited for the peculiar formation giving the fishing banks which produce our chief supply of fresh sea food. Our menace to-day is probably not so much the ice of the North Atlantic as irreparable disaster to the ice-formed fishing banks, the chief source of inexpensive fresh marine food for the masses.

WHENCE COMES THE BULK OF OUR FRESH FISH?

Georges Shoals is regarded by fishermen as the richest fish ground in the world, and the Georges cod, which are here found in great size and abundance, are said to be the finest caught. The shoal water, and the strong Bay of Fundy tide, and frequency of gales make these nearby sea-banks exceedingly rough and the record of disaster here is long and terrible.

Of late years improvement in design in the fishing vessels and method of fishing have diminished loss. February and March have seen the greater number of shipwrecks. On the evening of February 24th, 1862, a terrible gale from the northwest burst suddenly upon the fishing fleet on Georges, there being about seventy sail at anchor in a small space, for fish seem to congregate in comparatively small spots here. Without sufficient warning, they were unable to heave up anchors. Thirteen vessels with their entire crews were lost, largely through collisions, and two abandoned. Nearly every vessel was damaged—one hundred and twenty men lost, leaving seventy widows and one hundred and forty fatherless children.

Only a few vessels, known as "Georgiamen," ancient hulks with crews of old fishermen aboard, who use the hand line from deck, now anchor on Georges, so danger of collision from parting cables has been greatly lessened. The modern fishing schooner, with her yacht-like design, rides out the hardest gales, either under her foresail or with a triangular riding sail set in place of the mainsail, she "jogges it out." That is, with one small sail set and trimmed flat down, she is left to ride out the gale in the wind's eye. This she usually accomplishes in a remarkable seaworthy way.

How the fish are caught to-day may be illustrated from the notes written during a recent trip.

FISHING ON THE BANKS.

Saturday, March 16th:

Leave "T" Wharf at 10 A. M. Course east by south. Wind lightens toward evening and continues thus through the night.

Sunday:

East to northeast winds. We see a few schooners returning from Georges, and a steamship passes. Am awakened by the sawing of the lead line over the rail. It is shortly before daylight. We are in thirty-five fathoms of water, and on the northern edge of Georges Shoal.

Monday, Daylight:

The skipper from his bunk gives the order to "bait up." Breakfast is ready in the forecastle; the men are below in the waist of the vessel baiting the trawls (long lines with many hooks attached) with chopped-up frozen squid. Several schooners now come in view, some within a mile or less, others near the horizon. They also are preparing to fish. Soon the first dory of the string of ten is hooked upon the tackles, and lifted from the "nest" over the side. Two half kegs of baited trawl line are placed in each boat with a basket of extra squid bait. There is also a sail, two pairs of oars, gaff, fish fork, jug of water, a "girdy" or hand windlass to start the trawls, a pail, compass, some food, knife and anchor. Two dory mates tumble into the bouncing little boat and are cast off. One man rows, the other with a little stick, throws out the trawl line, hook by hook. As the vessel sails on, the other dories, first from one side then the opposite quarter, are put overboard, and set adrift about a fifth of a mile apart. The first dory is now but a speck in the horizon, seen occasionally as she rises on a sea. The schooner is headed back passing down her line of busy fishermen to leeward of the first boat, and hauls up to wait.

An oar is raised in one of the dories. The skipper bears down toward it—the vessel is thrown into the wind—the dory's painter is caught, and the men begin to pitch upon deck the catch with which they have loaded the boat. It consists of medium sized haddock and big codfish, many four feet long, weighing thirty pounds and over. Wooden partitions are set athwartships and held between the bulwarks and house by cleats, the cod and haddock being heaped in separate pens. Some of the fish are about all a man can lift on his three-tyne fork. Other boats which have become laden by this time are also picked up, some running down the wind with their sails. The deck pens grow in number and become filled to overflowing with silvery haddock, and huge, greenish, glasseyed, gaping-mouthed codfish. The dorymen hurry below for a "mug up"—hot coffee and tea—and a "layout" of ham, corned beef, potatoes, pies, doughnuts, bread and butter, cheese, and whatnot, spread by the cook on the racked table.

By the time this pair of dorymen has swallowed a substantial lunch effected with great rapidity, and are off again, another dory is alongside, with a heavy burden of still flapping fish. All day long, for this was an exceptionally good fish day, this program is repeated, the vessel ranging up and down, trying to keep run of the dories which are continually getting out of vision, some drifted away by the strong wind or tide, from others which have caught their gear on bottom and are "hung up" to windward. We counted twelve other schooners likewise tending their fishing boats. Just at dark, in a rising wind, the dories came for the last time, each being hoisted on deck and lashed down. The decks from the afterside of the cabin to the mainmast were now level full to the tail with fish, mostly large cod, thirty-five thousand pounds, the skipper estimated.

After supper the men hastened back on deck and under the light of a dozen flaring torches began to dress the fish. These were then washed in hogshead tubs, and when they were stowed away with chopped ice in the hold it was late in the night and the weary workers, save the two whose turn it was to be on half-hour watch, crawled into their stuffy bunks.

March 23rd:

Not a "fish day." Seas ran high and frequently came aboard as we "jogged out" the gale. In the afternoon it let up somewhat and the vessel headed for Browns Bank, some sixty miles away to the north. As we drew off the bank into the deeper water of the channel the sea became less disturbed.

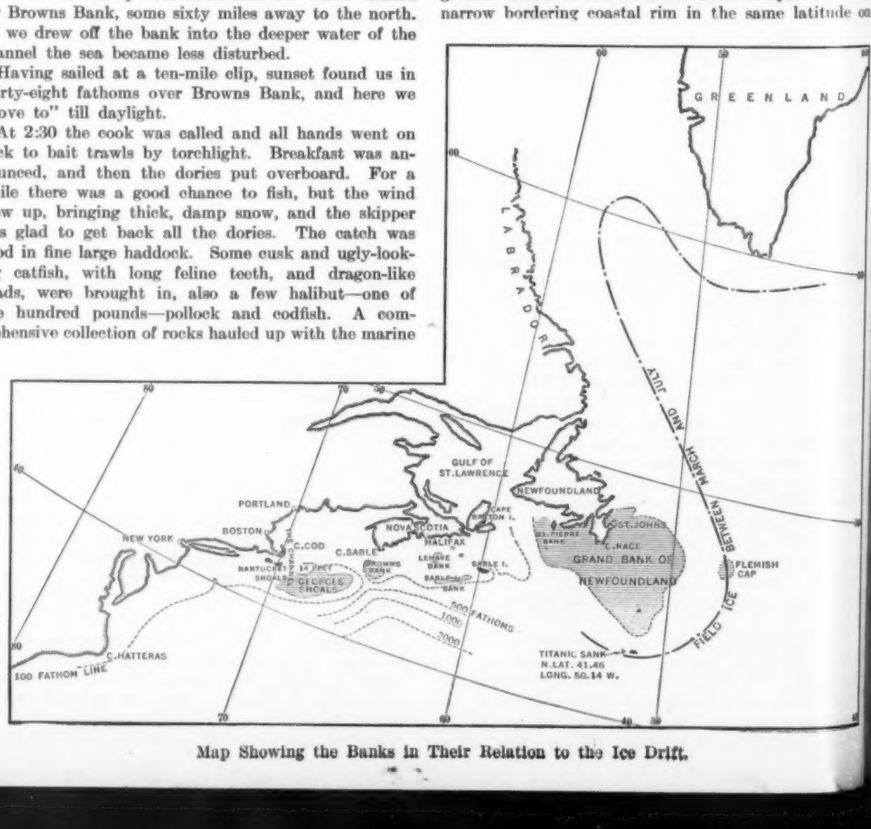
Having sailed at a ten-mile clip, sunset found us in thirty-eight fathoms over Browns Bank, and here we "hove to" till daylight.

At 2:30 the cook was called and all hands went on deck to bait trawls by torchlight. Breakfast was announced, and then the dories put overboard. For a while there was a good chance to fish, but the wind blew up, bringing thick, damp snow, and the skipper was glad to get back all the dories. The catch was good in fine large haddock. Some cusk and ugly-looking catfish, with long feline teeth, and dragon-like heads, were brought in, also a few halibut—one of one hundred pounds—pollock and codfish. A comprehensive collection of rocks hauled up with the marine growth attached was gathered. There were long-stemmed, stone lillies, crinoids, which the fishermen called "lemons," soft sea slugs or holothurians they called "pumpkins"—a yellow growth, termed "corn," sponges, and a large variety of other marine life. The rocks were of similar character to those of Georges, though seemingly of greater variety, somewhat smooth and rounded, but subangular. Quartz and quartzite predominated, both in sand and pebbles. Slates, granites, diorites, schistz, sandstones, similar to the variety usually found in glacial deposits on the neighboring shore, were abundant, testifying to the glacial origin of these sea banks.

Georges Bank is a shoal of the open sea, lying in the ocean about one hundred miles east of Cape Cod. The depth of this bank, which is roughly seventy miles square in extent, averages from fifteen to thirty fathoms, though in its middle portion there are spots with so little as fourteen feet of water over them, where in a storm seas run "mountain high." Between this shoal ground and the mainland there are depths of over a hundred fathoms, nearly nine hundred feet being found in spots, while on the eastern side the water falls off rapidly from the fifty fathoms to the one hundred, five hundred and one thousand fathoms line of true oceanic depths.

On the south between the lands of Cape Cod and the shoals of Nantucket is what mariners call "the Channel," with depths from fifty to one hundred fathoms, while to the north of Georges is another trough where the soundings average considerably over one hundred fathoms or six hundred feet. These "gullies" probably represent old channels once draining northern New England. On the north side of this deep gully lies a shoal ground of similar depth and character as "Georges," but about a third of its area, known as Browns Bank, some sixty miles off Cape Sable, Nova Scotia, from which it is separated by a moderately deep depression. These elevated portions of the sea bottom are so situated that they have long been the chief source of fresh fish supply for the eastern seaboard of the United States.

There are various other banks or off-shore shoals along the Nova Scotia, Cape Breton and Newfoundland coasts, terminating in the largest of all, the Grand Banks of Newfoundland. All these banks lie upon the comparatively shallow marine margin bordering the Atlantic coast, known as the continental shelf, which is usually assumed to be composed of the waste worn from the lands and deposited in the sea along the shore margin of its basin. It has been held indeed, that the greater width of this Atlantic shelf compared to the narrow bordering coastal rim in the same latitude on



Map Showing the Banks in Their Relation to the Ice Drift.

the Pacific side of the continent, has been gained through the laying down of a vast amount of detritus, the remains of lofty mountains whose roots alone now exist upon our north Atlantic coast. Be this as it may, another factor seems to have played a very important part in this upbuilding of the continental border, and appears to be the chief agent in the origination of at least the shoaler parts which constitute the best fishing grounds of North America and perhaps the world.

Two lines of deposits mark the southernmost limits of the great ice sheet, which occupied the northern portion of this continent in Pleistocene times. The outer moraine, where the materials brought by the glacier, sand, gravel and boulders, etc., were left, can be readily traced. On the Atlantic border of the southeast coast of Massachusetts, it largely built up the moranial islands of Nantucket and Martha's Vineyard, whose gently south-sloping plains represent the sands washed out from the old retreating ice-front, and whose rough and hummocky exterior or backbone are the irregular surface produced under the moving ice margin. This terminal moraine or "dump" continues westward, appearing again in "No Man's Land" and Block Island, and forming the "keel" of Long Island, whence it is traced through Staten Island, northern New Jersey, southern Pennsylvania, through Ohio to the junction of the Ohio and Mississippi, sweeping westward into Kansas, and then northward through Nebraska and Dakota.

The islands south of New England do not constitute the original limit of the glacial deposits, for the ocean has been eating back the land during thousands of years, and the sea of shoals which extends some forty to fifty miles to the south of Nantucket undoubtedly indicates their former extent. If the old channel of the Hudson River, which can now be traced in the coastal shelf, be taken as evidence, there is ground for holding that in the region of New York the land once reached over one hundred miles further to sea, during which time Boston's site probably lay twice that distance inland.

We have conclusive evidence that movements of the land along this portion of the Atlantic coast, both of elevation and depression, have taken place in the past, and are even going on at present. Old shore lines where changes of level of one hundred and sixty to three hundred feet are distinctly shown, occur on the islands and shores of the coast of Maine. Prof. Shaler stated his view that evidence of a change of level of over one thousand feet was to be found at Mount Desert, and detailed studies (by the writer) for the past two seasons, along the Maine, Nova Scotia, Cape Breton and Newfoundland coasts, have borne out this view.

At the time when the land stood at the very moderate higher elevation of some one hundred and twenty feet, Cape Cod would have extended five miles farther to the eastward, and the land about Nantucket thirty miles seaward.

Georges Shoal, under such conditions, might appear as an island over one hundred feet above the sea, resembling Nantucket and Martha's Vineyard, though of twice the size of their combined areas. The evidence is that such was a former configuration of the coast, and that there lay at a little over one hundred miles off the Massachusetts shore an island about half the size of Ireland, a true Atalantis "out at sea."

With the records of elevations and depressions along our coast of over a thousand feet in Pleistocene times, there is no difficulty in supposing the few feet of movement required to convert the shoales of Georges Bank into an island, further from the coast and greater in size than any now existing. The fable of the former presence of an Atalantis a hundred miles at sea, between Boston and New York, is thus seen to rest on rational geologic factors.

These fishing banks lie on the continental platform reaching along our Atlantic coastline, in form of a shelf gently dipping from the land into a hundred fathoms of water, where in a quick descent, it drops steeply to the thousand fathom depths of the ocean floor. Off Cape Hatteras the width of this shallow margin is but twenty miles, but this gradually increases northward until in the vicinity of Sandy Hook, it has a breadth of about a hundred miles, while off the New England shore it extends twice this distance to sea. The marked increase takes place as the southern unglaciated area is left, suggesting that the coincidence has connection with the extended submerged land rim.

The former southward extent of the southern New England morainal islands may be traced in the shoal water reaching near a hundred miles seaward, indeed there is now but a shallow channel separating Nantucket Shoals from Georges, which it would require but some minor change of level, when compared with what has taken place in the past, to join by continuous land. It is thus but a short step from the Georges Bank formation to that of the "Elizabeth Islands," and to hold that Georges and Browns Shoals are but underwater representations of the terminal moraine sand plains which lie above water to the westward. The materials drawn up from the fishing grounds bear out this view and moreover the general configuration of the open ocean shoals and their detail of bottom form, the kettle and kame topography and the backbone of irregular moraine deposit attributed to the overriding of glacial cover, seems traceable by soundings.

From the nature of these outer shoals lying on the continental shelf and confined mostly to the outer terminal moraine of the last ice advance, it is apparent that their extent is restricted to a comparatively small area, and that the searches for new fishing banks south of the terminal moraine will be fruitless. This limited distribution emphasizes the need for the careful conservation of the exceptional wealth of common food fishes, particularly the cod and haddock which flourish on these specially adapted habitats.

The banks are far enough from shore to prevent the smothering by fine coastal sediments of the multitudinous marine life, which here finds a pebbly bottom, cleaned by strong tides, on which it can attach itself, a most prolific sort of ground for the great schools of our finest food fishes.

It seems desirable that some action should be taken to protect the fish during the spawning season, at least for a period of years. There is also the greater danger that the now wholesale and destructive method of fishing with the steam trawler may cause irreparable and permanent damage to these natural feeding beds. This method which has already played great havoc with the fishing grounds of the European coasts, so that vessels which once operated about the British Isles must go as far as Iceland on the north and Portugal on the south for their catches, is at present being attempted in this country, and a gradually increasing fleet of steam "Otter" trawlers is now plying between the banks and the markets.

The beam trawler tows over the bottom a great open net which scours the ground like a giant harrow and engulfs nearly everything, big and little, with which it comes in contact. Not only does it disturb and destroy the delicate growths and fish food of the bottom, but vast quantities of small and unmarketable fish besides, that are crowded into the great open net maw and either smothered or killed when dumped on deck.

These trawls are ceaseless in their destruction, for they are towed under nearly all conditions and at night as well as day, while the line fishermen must wait for moderate weather. They also pick up, without discrimination, the sick and spawning fish which will not bite the baited hooks. This method of fishing tends to create a monopoly, as the costly steam vessels require large capital to build and operate and their increase will naturally tend to drive out the hardy independent men of modest means to-day engaged on the small schooners. These line fishermen are undoubtedly the best sailors we have to-day; they are resourceful, brave and efficient, largely because they all, crew, cook, and skipper, are either owners or share in every fare of fish. In time of war they form our best resource for first-class seamen. The beam trawler is operated by nondescript "steamboat sailors."

To judge the urgent need of restricting steam trawl fishing on this continent, we have but to glance at the present situation in Europe where beam trawl fishing has nearly put an end to the earlier methods, and it is necessary to go four times the former distance for fish.

Large numbers of small English and Scotch fishing towns have been obliged to give up the business, as Whitley, Scarboro, Stalhier, and Bradlington. The once rich Dogger Bank fishing has been, as a profitable industry, destroyed, and fish of the market size to which we are accustomed, have practically disappeared in nearby English waters. The European consumers are obliged to eat skate, ling, catfish and other "culch" which Americans do not use.

Nature has so arranged limited areas off our coast that they are veritable mines of self-perpetuating wealth, and inexpensive food for the people. Shall we, open-eyed to the overseas disaster wrought, run the risk of losing one of the last remaining natural sources of food supply which, with judicious use, may doubtless be saved for the future?

New Year's Celebrations in Japan

THERE is no occasion in the twelve months which is so looked forward to and celebrated with such *éclat* in Japan as New Year's Day, and the first half of January is so filled with festivities, days of special meaning and various observances of old customs supposed to bring good fortune during the coming year, that little else is attended to, or even thought of. Some of the usages (such as ringing the temple bells one hundred and eight times at the midnight hour, and many others) are similar throughout the islands, while certain practices and rites are peculiar and of special interest to different provinces and places. Foremost among these is the ceremony of the sacred fire, performed at Gion Shrine, Kioto.

About midnight the priest who is to perform the ceremony is carried to the shrine on a palanquin, preceded by torch bearers. In the corridors at either side of the hall of worship are twelve pieces of wood (representing the months of the year); six on each side. These are lighted, and the curling of the smoke therefrom carefully observed. If it drifts eastward, toward the province of Omi, or westwards toward Tamba, it presages a poor rice harvest to them, respectively, during the year following. The burning wood is then carried and shaped into a great fire in a huge iron basket swung in the temple court. This fire is held to possess great power to bring prosperity and happiness to those who succeed in lighting by its sacred flame a piece of rope, which must be kept alight until they reach their homes again, to start the fire for cooking their food the following morning. This is done by twirling the rope like a whirligig, and the glowing end, which burns like a cigar, but never flames, slowly eats its way until by the time the most distant devotees have regained their domiciles, but a small proportion remains. These ropes are sold by the thousands in booths which line the crowded streets and thoroughfares. They are little more than a yard long and about one-half inch in diameter and the priests at the temple on the hill are kept busy lighting these ropes, praying the while. The returning thousands with as many revolving wheels of fire of every size, as the whirling rope is shortened or lengthened by its possessor, make a wonderful sight, and it seems little short of a miracle that the flowing sleeves and robes do not catch fire.

In Tokio, New Year's Day is the most strictly observed holiday of all, and excepting fruit dealers, scarcely a shop can be found with open doors. The streets are thronged with men in carriages, jinrikishas and afoot, hurrying to make the round of their circle of acquaintances, usually leaving cards for which beautiful lacquered trays, resting upon some exquisite piece of old brocade, are placed at the door. The streets are also gay with children, girls in frocks of vivid colors, and boys, flying tremendous kites. Minstrels and dancing girls in fancy costumes and masks go from house to house, playing and singing at the doors, to receive a few pennies. Many of the old customs have been laid aside as superstitions have yielded to education and Western ideas have permeated the new Tokio. But one of the New Year's celebrations practiced from ancient times is still observed. This is the first consignment parade (hatsumi) which takes place on the second day. It is made up of employes of tradesmen, and workmen, who, in their blue coats with the name of the firm they represent on their backs, walk alongside the decorated carts which are laden with the first consignment of goods from the wholesale house to their employers. So-called musicians, playing on Japanese and foreign instruments, head the procession. Another celebration held in Tokio every New Year is the one by the fire brigade, which gives a public exhibition in one of the parks, showing their skill and training.

On the 10th of January a peculiar rite is performed by merchants at the shrine near the City of Osaka; while on the 15th great bonfires are made of articles and materials used for the New Year decorations. This is the last of the celebrations, and all suggestions of the holiday season seem to disappear like magic. —*Japan Magazine.*

Formation of the Earth's Surface

AT a recent meeting of the Geological Association at Frankfort-on-the-Main, Dr. Wegener, of Marburg University, suggested an interesting hypothesis on the genesis of the Earth's surface. According to this, the present form of the surface would be due to vertical and horizontal displacements. The continental blocks, i. e., the different parts of the world, such as Europe, America, etc., are capable of vertical displacement, like blocks of floating ice. As soon as an increased load is brought to bear on them, the blocks will sink down. Such an increasing load may be due to the continental ice covering the country. According to the author's preliminary calculations, a load of 2.6 meters of ice would entail a drop of 1 meter. Horizontal displacements likewise occur continually, as shown by the relative displacement of continents. Lunar observations for instance show Greenland to have moved 940 meters farther away from Europe in the course of 84 years. On the other hand, determinations of the distance between Greenwich (England) and Cambridge (America), have revealed the surprising fact that North America, in the course of 26 years, has withdrawn another 90 meters from Europe.

Foot Inclosed in Conventional Shoe.

The Bare Foot.

Foot in the New Army Shoe.

Scientific Foot Treatment for the Army

Trying on Shoes by X-Rays

After four years of exhaustive experiments the Board of Army Officers appointed to study foot troubles of United States soldiers with a view to offering a remedy has completed its work and has recommended the adoption of a new kind of footwear—a perfect fitting shoe.

Under the old regulations shoes of two patterns were ordered, one a straight and the other a slightly curved last, neither of which, however, gave satisfaction on long marches, and for years the percentage of imperfect feet in the army has been appalling. On long marches men have been forced to drop out of line on account of blisters, bruises and other shoe troubles. The new shoe, which the board has been so long in perfecting, has a low flat heel, a broad round toe and a quarter of an inch more swing or curve than the old style, the straight last having been abandoned altogether.

The investigations carried on by the board were of the most complete and painstaking character, and X-ray photographs resulted in some very interesting information as to the effect on the feet of standing in certain positions, and marching in both heavy and light equipment. Civilians might study these tests in shoe fitting with beneficial results, especially those troubled with aching feet. The heaviest tests were made with the soldier in his full uniform and carrying the maximum amount of equipment of 40 pounds. In the course of these investigations the tendency of the feet to spread as the weight was thrown on them, was fully studied, and the X-ray shows the position taken by the various bones of the feet as affected by the changing position and weight. Photographs showing some remarkable experiments have been taken of the feet in the old-style shoe with 40 pounds of pressure on the soldier's back, and the same foot in the new shoe. Invariably in the old shoe some of the toes were pushed completely out of their proper position, but in the new shoe each toe has plenty of room, thus making marching with full equipment as easy as possible.

The board during its labors examined thousands of soldiers' feet under varying conditions, carefully taking note and making report on each foot where trouble was caused by a shoe. These feet were also measured and photographed in every conceivable position, ranging from the most complete repose to the severest possible strain under the conditions of service.

In the final tests at Fort Leavenworth the new sh proved beyond doubt the success of the board's ardu work. A march of nine days, covering 118 miles, w made by 375 men. Part wore the old-style shoe and th others the new shoe. The latter finished the tra easily, while a great percentage of those equipped wi the old-style footwear were forced to quit on account shoe trouble.

The method now adopted by the army for "breaki in" new shoes and making them conform to all the lit quirks of individual feet, resulting in a perfect fit, unique. After the shoes are fitted to the soldiers' fe they are made to stand in water to their shoe tops un the leather is thoroughly soaked, then they are marche around until the shoes have dried on their feet, when fo ever after the new footwear is as comfortable as t proverbial "old shoe." This may seem a somewhat here method, but in practice it is found thoroughly effectiv

The new shoes will be made both in black and ta the former to be used with the blue uniform and wi full dress and the latter about the garrison and in th field.

The Permeagraph

A Graphical Machine for the Magnetic Testing of Iron and Steel

By Nathan C. Johnson, Research Fellow in Mechanical Engineering, Cornell University

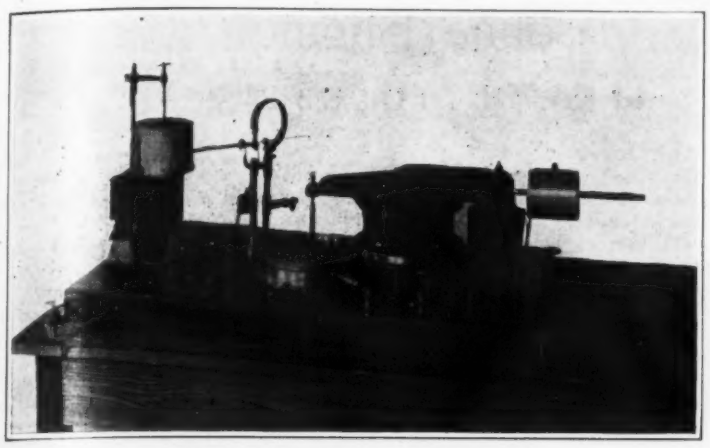
The determination of the magnetic properties of iron by any of the ordinary ballistic or magnetometric methods commonly in use is at best a tedious and cumbersome process. Without regard to the process employed, it may be fairly said that the nature of the operation and the apparatus is such that only in the hands of a skilled operative and at the expenditure of much time and patience can good results be obtained. Further, for a comprehensive view of the results obtained, the instrument readings have to be laboriously plotted on cross-section paper, with often the added inconvenience of deriving these plotted points from the instrument readings.

With a view to overcoming these difficulties and at the same time of obtaining permanent, comprehensive records that could be readily filed away, the machine presented herewith, which the writer ventures to call the "Permeagraph," has been divised. It presents several features not contained in any other apparatus and it is believed that it will find a considerable field of usefulness.

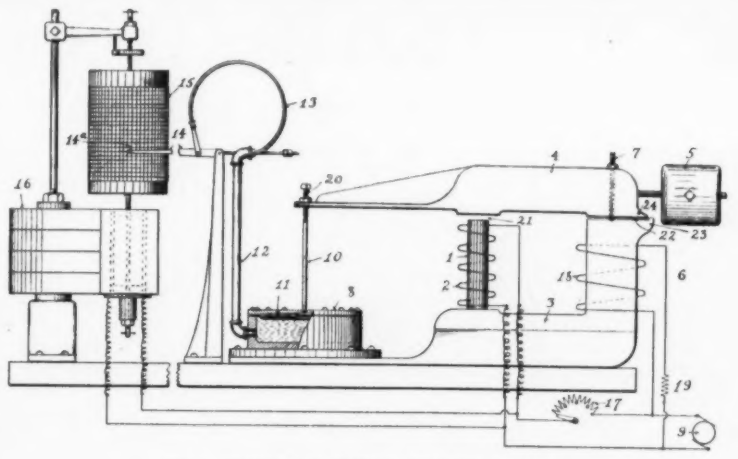
In much commercial testing of iron, comparative results graphically presented would be sufficient for every ordinary purpose where the iron under test is compared to a sample of known properties. Such comparative curves for different irons are shown in the attached print, Fig. 1. These curves were traced by the machine and have not been corrected in any way. The properties of the irons is evident at a glance; and with proper calibration, the exact qualities of each could be scaled off without trouble.

The curves shown in Fig. 1 were taken with carefully prepared samples, that is, the length and cross section of each is the same and one end of each has been accurately surfaced off. This, however, is not always necessary. The curves shown in Fig. 2 have been obtained with a sample of transformer iron which has simply been cut from the sheet with snip shears and placed on the top of the standard sample in the machine. The curve of the standard sample is the lower one. The curve of the transformer iron is the upper and the properties of the latter can, if needed, be readily deduced therefr

These matters will be better understood by refer to the construction of the machine, as shown in the pr By reference to the photograph and diagram, it wil seen that in general the device consists of a means measuring the induction of the sample by means of attractive power on a movable yoke, which is part closed magnetic system; and of a drum (15) carryi piece of paper for the record, actuated by a D'Arso system (16) in shunt with the magnetizing coil More particularly, the magnetic circuit consists massive frame (3) and a movable yoke (4) whose netic reluctance as compared to the flux to be induce the sample (1) when excited by the coil (2) is made small. The yoke (4) rests on two needle points at (7 the lower part of the yoke; and is counter-balanced the adjustable weight (5). The yoke (4), also has extension, preferably of non-magnetic metal, on its ward end, carrying the cone-ended adjusting screw From this screw a double-pointed steel pencil (10)



The Permeagraph, View in Perspective.



View, Partially in Section, Showing Details.

tends downward and bears on a corrugated copper diaphragm (11), covering an oil reservoir (8). From this reservoir, a pipe (12) leads to a Bourdon tube (13), the whole system of reservoir, pipe and Bourdon tube being icompetely filled with kerosene oil. Connected to the free end of the Bourdon tube by means of a straight line motion (not shown in the photograph) is the arm (14), carrying on its outer end a V-shaped pen, such as is commonly used on recording instruments. This arm (14) is counterbalanced by a small adjustable weight.

From the preceding, it will be seen that by this construction, we have left three air gaps in the magnetic system, i. e.: one where the sample rests on the lower part of the yoke; one between the upper end of the sample and the movable, upper part of the yoke; and one between the upper and lower portions of the yoke.

The last of these is almost wholly eliminated by grinding the surfaces in contact and properly adjusting the screws (7). The first one—that between the bottom end of the sample and the yoke—is also made as small as possible by careful grinding of the surfaces; and the effect of this is also made as small as possible by making the gap at the other end of the sample relatively large. It will thus be seen that so far as the magnetic circuit is concerned, we shall have a means of measuring, through the movement of the pen attached to the Bourdon tube, the induction in the sample (1), due to its attraction of the yoke (4) and the resultant pressure on the diaphragm covering the oil reservoir.

The operation of the apparatus is simple. The D'Arsonval system actuating the drum is, as before stated, in shunt with the magnetizing coil around the sample. This gives us H on the curve. The pressure exerted on the diaphragm actuates the pen, giving us the values of B^2 corresponding. It is true that to get this latter motion, we have some motion of the diaphragm, which means some motion of the arm of the yoke (4), with consequent lessening of the air gap between (4) and the sample (1). But this motion is that corresponding to the change of volume of the Bourdon tube in altering from the elliptical to the circular, with a 3/32-inch maximum movement of the free end; and this change of volume is distributed over the area of a 9-inch diaphragm; and this movement of the diaphragm as related to the air gap is lessened by the ratios of the distances of the screw (20) from the screws (7) and that of the center line of the sample (1) from the screws (7), so that it may be taken as negligible. With the maximum induction obtainable in soft Swedish iron in the machine shown in the photograph, this lessening of the air gap is 0.0008 inches.

In inserting a sample in the machine, the yoke (4) is lifted. A bracket (23) at the back of the frame takes the weight of (4) in so doing and relieves the needle points (7). The sample in place (4) is again lowered until the screw (20) rests on the steel pencil (10). The current is then increased steadily by means of a water rheostat, or other rheostat giving a smooth curve; and if the pen has been placed in contact with the paper on the drum, a B^2-H curve for the sample will be traced. When a maximum is reached, the current is decreased to zero, thus tracing half of the hysteresis loop. Residual magnetism in the sample will hold the pen above zero; and when the current is again gradually increased after reversal, the opposing induced flux will first bring it to zero of B, then cause it to rise again. In this way, a complete and accurate hysteresis loop may be traced by even an unskilled operative in about two minutes, the only limiting feature as regards time being the lagging of the induced magnetism in the sample behind the inducing force. This soakage effect requires a slow and steady varying of the current for best results.

It will be noticed from Fig. 3 that the hysteresis loop has both horns above the axis of x. This is because the pressure is expressed positively only. If it is desired to have this appear in the customary form, one-half of the loop may be turned over.

While the hysteresis loop may be quite accurately taken in this way and the loss determined by integration, it is recognized that the better way to determine iron losses is probably by some method such as the Epstein, or by the improved apparatus of Burrowes. The province of the Permeagraph is the rapid, comparative testing of irons.

In this connection, the method of determining the quality of transformer iron without accurate preparation of the sample, should be referred to again. All that is necessary to do is to cut off a piece of the sheet sufficiently large to cover the end of the sample—in the machine shown, the sample being 1¼ inches in diameter. After running a curve with the standard sample, place the small piece of sheet metal over the end. Then run the curve again. It will be seen that this curve is quite distinctive, for by cutting down the air gap between the sample and the yoke to the extent of its permeability, the value of B will be increased and this increase will be registered by the pen. It matters not what sort of contact this small piece makes with the yoke or the sample. The resistance of the air gap will be decreased by its presence and this will show in the increased attraction of the yoke (4).

Friction between the pen and the paper on the drum is eliminated by mounting a vibrator on the pen standard and so adjusting the pen that contact with the paper is made through a minute drop of ink. The vibrator shakes the pen enough to cause it to draw the line without more than instant contact at any tine.

An obvious refinement would be to make the sample longer in proportion to its diameter; and to fashion the pole pieces to secure concentration over the air gap (21) between the yoke (4) and the sample and to diminish leakage. Further, an auxiliary coil (6) wound over the back of the yoke, excited by a current having a constant value such that the flux induced in the yoke will just overcome the reluctance of the yoke and the air gap has assisted in giving good results. All these refinements are not shown in the photograph, which was taken before they were added to the machine; but with their aid, results have been obtained which warrant the writer in believing this device will find place in commercial work.

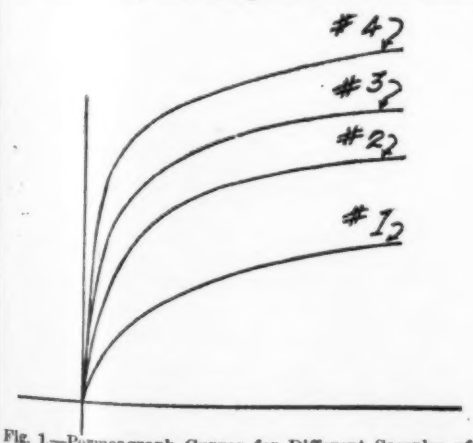


Fig. 1.—Permeagraph Curves for Different Samples of Iron. 1. Cast Iron. 2. Machine Steel. 3. Swedish Charcoal Iron. 4. Annealed Laminated Steel.

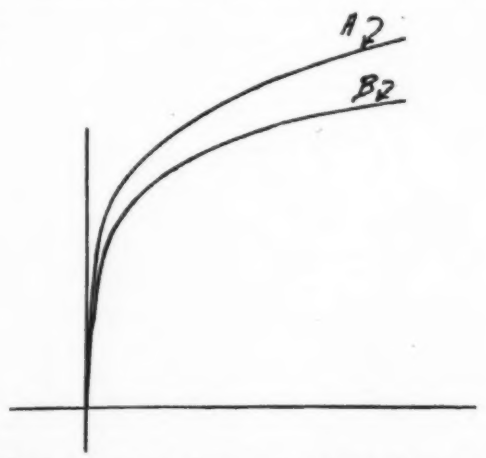


Fig. 2.—Curve of Transformer Iron Obtained by Placing Sample on Top of Standard Sample and Running the Curves. Curve *A*, Standard Sample With Transformer Iron. Curve *B*, Standard Sample Alone.

How Accidents Originate.—The Imperial Insurance Department of Germany recently published data concerning the causes of accidents, which are interesting as well as instructive. The figures, as given below, do not, however, cover all accidents reported, but only those for which damages had been recovered:

		%
1. Motors, transmission, machine work	14,094	20.3
2. Lifting appliances (elevators, cranes, hoists)	3,097	4.5
3. Steamboilers, steam conduits	158	0.2
4. Explosions and explosives	552	0.7
5. Combustible, hot and caustic substances (gases, vapors)	2,208	3.6
6. Collapsing, demolishing; dropping and falling objects	11,012	15.5
7. Fall from ladders and stairs; excavations, hatchways, etc.	10,451	15.1
8. Loading and unloading; carrying and lifting	8,630	13.0
9. Vehicles (running over or falling off)	4,469	6.5
10. Railways	5,059	7.3
11. Navigation and traffic on water	573	0.8
12. Animals (blow, thrust, bite)	1,032	1.6
13. Tools and implements	4,611	6.5
14. Other objects or events	3,365	4.4
Total	69,311	100.0

From these figures we learn that but 24 per cent of all accidents fall to modern machine operations. The majority, nearly 45 per cent, are the results of gravitation (calling, lifting, carrying), while transportation causes about 14 per cent of these accidents. The figures also show that neither the increase in the number of persons insured, is the cause of the growing number of accidents, nor are these caused by the extended application of elementary forces (at the expense of hand operations), as is generally supposed.—*Zeitschr. f. Gewerbe Hygiene.*

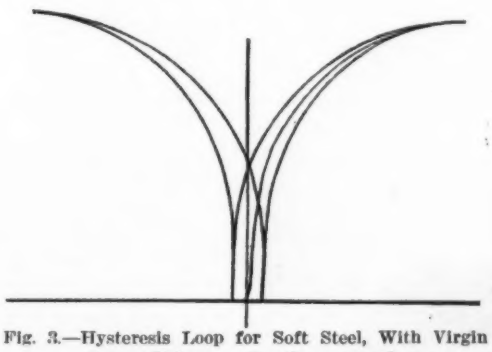


Fig. 3.—Hysteresis Loop for Soft Steel, With Virgin Curve, Taken on the Permeagraph.

Lubrication Problems in Gasoline Engines

High Temperature of Cylinders Makes Special Demands on Oil Employed

By Theo. M. R. von Kéler

WHILE railroad engines, ship's engines and similar huge "traveling" machines—not to speak of the thousands of stationary steam engines of all kinds and sizes—have been in use long enough to solve all the problems connected with the proper lubrication of their various reciprocating parts, the recent rise of the internal combustion engine, particularly as applied to automobiles, motor boats and aeroplanes, has brought forth new factors in the selection of a lubricating medium which will fulfill all requirements. To the ordinary automobilist, and even to the average garageman, one oil is pretty much the same as the other, provided it fulfils the specifications as to color and specific gravity, but to the expert there is as much difference between two oils of the same color and same specific gravity as there may exist between a dark brown and light yellow oil. They may both be "good" in the general way of talking of oils, and yet one may be actually damaging the motor and poisoning the air, while pretending to render good service. To distinguish between the two is not easy, and requires the services of an experienced chemist and several weeks of careful and painstaking investigation.

It is not by any means true that a good bicycle oil, or sewing machine oil, will give a good oil for automobile use. It may do for lubricating some of the parts, that do not come into contact with the motor itself and its great heat, but for use in the cylinders of an internal combustion engine it would be almost as bad as no oil at all.

The peculiar conditions existing in the cylinders of a gasoline motor, which are entirely different from those prevailing in the cylinders of a steam engine, are primarily due to the extreme heat generated in the gas engine. When the mixture of gasoline and air is exploded by the electric spark immediately after the compression stroke is finished, the temperature in the cylinder reaches 1,400 deg. Cent. (2,652 deg. Fahr), which, of course, is many times greater than the temperature existing in the cylinders of the steam engine. Besides, the speed of the piston in a gasoline motor is considerably greater than the highest speed ever attained by that of a reciprocating steam engine. Exactly what process takes place at the moment of the explosion of the compressed gas mixture, in regard to the small quantity of lubricating oil which is present, is still a mystery. It is doubtlessly true that a not inconsiderable part of the oil burns and is forced into the exhaust pipe. How much of the oil is destroyed, and how much remains to do its duty as a lubricator, depends on the composition of the lubricant, and the cooling arrangement of the motor.

There is no doubt that the destruction of the oil by combustion cannot be averted; a certain quantity of the oil *must* burn, and *must* find its way in this burnt state into the exhaust pipe. If this combustion can be made complete, in so far as the burnt part of the oil is concerned, it follows that there will be less residue and less "smoke." A very thick oil, composed of fractions with a high boiling point, naturally will be only partially burned, which would explain the almost universal demand that cylinder oil be medium thick and possess a comparatively low boiling point—just the opposite from what the average driver or owner of a car would imagine would be necessary. The part of the oil which burns, must burn completely and should not leave a carbon deposit in the cylinders. The more carbon there is in the oil, the more oxygen is necessary to complete combustion. Oxygen, however, in a gasoline motor is a precious substance and practically the entire supply drawn into the cylinder on the suction stroke is needed for the combustion of the gasoline itself. The small quantity not thus employed is sufficient for complete combustion of the oil only when the latter does not contain too much carbon.

A further result of such incomplete combustion of the lubricating oil is the offensive odor of the exhaust gases. Properly handled and lubricated, the exhaust gases of a gasoline motor should not contain anything but carbon dioxide and water. If there is any other substance present it shows that combustion has not been perfect and that the motor is not working at its full capacity. Carbon monoxide, and unchanged hydrocarbons usually accompany the exhaust gases of the average automobile; the difficulty in this case lies in poor carburation. Where the carbureter is adjusted properly and offensive odors still proceed from the exhaust pipe, the quality of the lubricant used is at fault.

For some time it was believed that a small addition of so-called "fatty" oils—oils of organic nature—would be of value in lubricating automobile motors, but careful analyses have proved that such is not the case. Fatty oils, when burning, leave a considerable residue of carbon, and it was found that the addition of such oils to the gasoline-motor lubricant results in an immediate increase in the deposits of carbon in the piston rings, cylinders and valves.

In order to determine with some degree of certainty the best possible composition of lubricating oils for gasoline motors, a series of tests has just been finished in the Royal Experimental Station for Testing Materials, at Berlin, Germany (*Koenigliches Materialprüfungsamt*) which disclosed some unexpected and highly valuable properties of oils of different chemical composition. It was thought plausible at the beginning of the experiments, that a division of the oils to be examined into their light and heavy parts, respectively, would

TABLE A. GAS MOTOR AND AUTOMOBILE OIL TREATED WITH ACETONE.

		Weight in Per Cent.	Color and Transparency in Test Tube of 5/8 Inch Diameter.	Specific Gravity 15 Deg. Cent. (Water = 10,000)	Viscosity at 20 Deg. and 50 Deg. Cent. (Water at 4 Deg. Cent. = 1). 20°	50°	Ignition Point (Open Apparatus).	Burning Point.
							Centigrade.	
1.	Gas motor oil of unknown origin	...	light brown, clear	9,040	67.4	10.1	211	259
	After triple treatment with equal quantity of acetone: insoluble	83	"	8,950	65.7	10.4	222	267
	soluble	17	"	9,531	94.6	9.8	...	...
2.	Russian automobile oil	...	red, clear	9,060	60.6	9.1	207	260
	After triple treatment with equal quantity of acetone: insoluble	81	"	8,970	58.8	9.2	219	263
	soluble	19	"	9,520	82.9	9.2	186	235
3.	Thick American automobile oil	...	dark red, transparent	8,915	....	....	256	316
	After triple treatment with equal quantity of acetone: insoluble	93	"	8,876	....	....	265	321
	soluble	7	opaque	9,566	....	....	...	...
4.	German automobile oil	...	light brown, clear	9,159	37.7	5.9	208	252
	After triple treatment with equal quantity of acetone: insoluble	66	"	8,959	43.6	6.9	215	257
	soluble (1)	14	"	9,657	48.4	6.3	198	241
	in three (2) treatments (3)	12	"	9,552	43.6	5.7	191	237
		8	yellow, clear	9,471	40.1	5.5	196	246
5.	German automobile oil	...	light brown, clear	9,207	54.1	7.6	207	261
	After triple treatment with equal quantity of acetone: insoluble	70	"	9,018	95.8	8.2	216	275
	soluble (1)	12	dark brown, clear	9,753	84.0	8.9	...	...
	in three (2) treatments (3)	10	"	....	....	....	...	...
		8	dark yellow, clear	9,549	62.9	7.8	...	...

The acetone treatment was accomplished by thoroughly shaking the oil for five minutes each time with equal volume of acetone at 20 deg. Cent.

TABLE B. I. QUALITIES OF AUTOMOBILE OILS.

(a) Oils of the Consistency of Machine Oils.

No.	Color and transparency in 5/8-inch test tube.	Viscosity (water = 1) at 20°	50°	Blazing (ignition) point in centigrade.	Origin and constitution.	Remarks as to work performed in actual factory practice.
1	Red, clear	24.2	5.2	195	pure mineral oil	Worked well with 4-cyl. motors of 15 and 62 horse-power.
2	Red, clear	25.2	5.1	193	"	A good oil for cylinders.
3	Brown-red, clear	26.4	4.46	195	"	(Same as No. 1.)
4	Red, clear	32.3	5.9	213	"	Especially good in motors for trucks and buses.
5	Red, clear	34.4	6.4	139	"	Satisfactory in motors up to 22.3 horse-power.
6	Red, clear	52.7	8.0	196	"	Very good for small motors and motorcycles.
7	Yellow, turbid	53.9	6.6	126	"	Satisfactory in motors of various horse-powers.
8	Red, clear	60.6	9.1	198	"	Very good for high-powered motors running at great speed
9	Dark green, opaque	66.8	8.4	219	"	Satisfactory in motors up to 15 horse-power.
10	Red, turbid	66.8	9.1	195	"	(Same as No. 7.)
11	Reddish brown, clear	68.8	9.6	224	"	Extremely satisfactory for all-around use.
12	Light brown, clear	69.9	9.2	211	"	(Same as No. 4.)
13	Opalescent green, red	70.1	8.5	175	"	(Same as No. 1.)
14	Red, clear	74.5	11.1	204	"	(Same as No. 4.)

(b) Oils of Medium and High Viscosity.

No.	Color and transparency in 5/8-inch test tube.	Viscosity (water = 1) at 20°	50°	Blazing (ignition) point in centigrade.	Origin and constitution.	Remarks as to work performed in actual factory practice.
15	Green, turbid	128.0	8.3	207	pure mineral oil	Satisfactory for gears, etc.
16	Dark green, opaque	...	9.6	206	fatty mineral oil	Left carbon deposits in cylinders.
17	Opalescent	365.0	10.3	209	pure mineral oil	(Same as No. 4.)
18	Red, clear	121.9	11.7	208	"	(Same as No. 8.)
19	Reddish brown, clear	83.2	13.4	235	"	Good for cylinder use.
20	Red, translucent	101.3	15.1	239	"	For all kinds of motors.
21	Red, translucent	...	15.9	215	"	For all kinds of motors.
22	Red, clear	139.4	16.6	229	"	(Same as No. 8.)
23	Red, translucent	...	18.8	237	"	Good for both cylinders and gears.
24	Dark green, opaque	...	26.4	244	"	
25	Red, translucent	...	30.2	278	"	
26	Dark green, opaque	...	36.0	238	fatty mineral oil	Left deposits in cylinders.

NOTE:—Sample No. 16 was of vaseline consistency at ordinary temperature, while Samples Nos. 21, 23, 24, 25, and 26 were still heavier.

II. GAS-MOTOR OILS.

No.	Color and transparency in 5/8-inch test tube.	Viscosity (water = 1) at 20°	50°	Blazing point in centigrade.	Origin and constitution.	Remarks as to work performed in actual practice.
1	Yellow, slightly turbid	12.4	3.44	211	fatty mineral oil	Fairly good motor oil.
2	Yellow, clear	13.5	3.4	201	mineral oil with 5% bone oil	Used in gas motors of 25, 100, 300 horse-power without detrimental effects.
3	Yellow, clear	16.4	3.82	218	pure mineral oil	Very good motor oil.
4	Yellow, turbid	19.0	4.81	169	fatty mineral oil	Did not work well.
5	Reddish brown, clear	21.6	4.04	184	pure mineral oil	Good, but great quantity used up by motor.
6	Yellow, clear	22.8	...	...	fatty mineral oil	Suited for cylinders in small motors.
7	Dark yellow, turbid	23.4	4.62	196	mineral oil with 3% bone oil	Good motor oil.
8	Dark yellow, slightly turbid	31.7	5.8	191	fatty mineral oil	Did not work satisfactorily.
9	Yellow, turbid	...	6.7	199	pure mineral oil	Very good all-around oil.
10	Red, slightly turbid	50.8	7.8	145	"	Good for large gas motors.
11	Brownish red, turbid	70.1	7.8	202	mineral oil with 2.4% organic fat	Gave poor service.
12	Light brown, slightly turbid	77.4	10.5	...	pure mineral oil	Excellent in large gas engines, particularly in Diesel motors.
13	Reddish brown, clear	...	8.2	...	"	Left deposits on pistons and piston rings.

tend to show exactly which substances burn easily and which burn with difficulty in cylinders. For the purpose of accomplishing such a division acetone was selected. Acetone has the quality of dissolving the heavier portions of mineral oils, while leaving undissolved those of low specific gravity. Both the heavy and light portions were tested for their tendency to become resinous, and it was then found that the heavier parts turned to resin much more quickly than the lighter parts (see Table A). The supposition was that those parts which turned to resin most easily would also prove to offer more resistance to complete combustion in the cylinder, and would develop more offensive odors than lighter oils.

In order to test this supposition, oil No. 4 (Table A) was used in an automobile, and immediately afterward that portion of the same oil which was found insoluble in acetone. The oil tank on the car was cleaned carefully and then filled with oil No. 4. The engine was then run at high speed—the car itself remaining standing—and a great quantity of the oil admitted to the cylinder. The odor of the dark blue clouds issuing from the exhaust pipe was exceedingly offensive. The oil tank then was emptied and filled with oil which had been treated with acetone. Running the engine under the same conditions, again with a superfluity of oil, resulted in the same heavy clouds, but the disagreeable odor was entirely absent. The car was then run for a considerable distance with the two oils, and it was found that under normal conditions the "treated" oil would give no clouds, and the little odor which was noticeable was by no means disagreeable. On the other hand, the original oil developed a smoke which irritated the eyeballs and nasal passages almost to the point of inflammation.

This test proved conclusively that the offensive odors issuing from the exhaust pipe of many automobiles are chiefly due to the presence of oils of certain high specific gravity. As the other oils in Table A, when treated with acetone, also gave heavy and light portions of similar constitution as those composing the sample No. 4, it was taken for granted that they would give the same results if submitted to the practical running test. The test with acetone, therefore, should prove a valuable means of proving whether or not a certain oil contains substances capable of causing the offensive odors, after accomplishing their lubricating work. It proves also that the various means taken or proposed which are to do away with the nuisance of smoking automobiles do not attack the problem from the correct point. It is not so much a question of absorbing or deodorizing the exhaust gases, as it is a proper selection of the oil best suited for the particular motor in which it is to be used. And this selection should not be made by some sort of "rule of thumb" method, but by a careful analysis based on the acetone method. Once decided upon as the best, the oil selected can undoubtedly be obtained from the manufacturers. It would even be possible to divide the oils into specifically light ones for automobile use, and heavy ones for steam-engines—or to treat them with acetone before marketing them.

In reference to the tests reported and tabulated in Table A, it may be added that in all oil samples treated with acetone the viscosity of those portions insoluble in acetone is smaller, and the flashing and boiling points higher than those of the soluble portions—excepting samples No. 4 and 5.

An examination of Table B proves conclusively that lubricating oils for automobile-cylinders should be of mineral origin, light colored, of a viscosity of not more than 13 and not less than 6 (water at 20 deg. Cent. = 1) at 50 deg. Cent. It is also of importance that the percentage of paraffine should be as small as possible in order that the oil may be easily conducted to the spots that are to be lubricated. A large percentage of paraffine would cause the oil to coagulate in cold weather and naturally would prevent a free flow. The two samples, Nos. 16 and 26, contained a considerable quantity of fatty substances, which explains their poor showing. The same table also shows that the horse-power of the motor has nothing to do with the quality of the oil, the same oil being used for motors of various horse-power, and, on the other hand, the same motor being well lubricated by oils of different viscosity.

The samples 1 and 3 (Table B, Ia) were used by a well-known automobile manufacturer for the lubrication of four-cylinder motors of 15 and 62 horse-power, respectively; later on the same motors were lubricated by a far thicker, cheaper and darker oil (No. 13 in Ia) which renders the same good service. It was found that the oil ducts in these motors were so constructed that the viscosity of the oil was of practically no importance.

Aside from the treatment of lubricating oils with acetone, the science of chemistry knows of no method of analysis at present, which permits of a correct valuation of lubricating oil for combustion motors. Research is going on in practically every large laboratory and especially in the great automobile factories and oil refineries, but so far no satisfactory method has been found, by which the quality of an oil for automobile use can be ascertained in the laboratory. It is, however, expected that further tests along the line of acetone treatment will evolve a fairly easy, and yet trusty, method of judging the suitability of the various kinds of lubricating oil for automobile use.

Radiotherapy

RADIOTHERAPY seems now sufficiently well established among the physicians of repute in the treatment of certain diseases to render a conservative consideration of its merits, both timely and profitable. The subject is well handled by M. Marcel Molinié in a recent number of the monthly supplement issued by the publishers of the French encyclopedia *Larousse*.

The gratifying results obtained by Finsen and others with lamps giving off X-rays, naturally suggested that the emanations from radium salts and radio-active waters might be similarly useful.

The first destructive effect on the tissues of this new substance discovered by the united genius of Mme. Curie and her late husband was noted by the eminent chemist, Becquerel. Having carried in his pocket for several hours a glass tube containing a radio-active salt he found himself suffering from a burn located beneath the tube. This was at first comparatively painless, increased in severity to a pretty serious maximum stage and then gradually healed.

This ability to alter tissues by destroying or modifying them is made use of in radiotherapy to interfere with the growth of morbid tissues. "These," says Molinié, "being generally of recent formation, are more sensitive than the adjacent healthy tissues of greater age. Radium seems to exert upon such tissues a sort of electric action, attacking them without inflammation and inciting a retrogression.

"To accomplish this a complete technique was evolved in 1905 by Drs. Wickham, Degrais, and Dominici, their chief aim being to select the utilizable radiations from the total of those emitted, and so to control the manner and periods of application as to avoid burns and other undesirable features.

"The variable penetration of the rays permits of their separation. Thus, those of the alpha group are stopped by very slight thicknesses of metal, the beta rays are capable of penetrating much thicker layers.

"Certain rays of great penetrative power are not checked by two millimeters of lead, and the gamma rays are effective even beyond a metal screen several centimeters thick. Hence, the filtered radiation will always contain gamma rays and a variable proportion of beta rays according to the thickness and the nature of the interposed screen."

The method of procedure consists in inclosing the radium salt (the bromide or sulphate), either pure or diluted in an inert substance, in a small sealed glass tube (the sealing being done by melting the glass), and placing this in an easily replaceable metal receptacle. This may be of aluminium varying in thickness from a hundredth to a tenth of a millimeter in thickness; or it may be of lead, silver, or gold of a thickness up to three millimeters.

To obtain a deep-seated influence without alteration of the skin and superficial tissues the tube should be of lead, the rays then having great power of penetration. On the other hand the tube should be naked or coated with a delicate film of aluminium for surface application; in which case an equal use is made of screens of cloth coated with a radium salt or simply spread with a radiferous varnish.

The time of action varies from a few minutes to several hours. Short contacts frequently renewed are preferable in general. The application is sometimes made by the use of screens shaped to suit the part affected and placed in contact with it or very close to it. Sometimes tubes are employed and inserted in natural passages such as the œsophagus, etc. Or by the aid of the bistoury a still more intimate situation of the appliance may be secured.

Molinié states that excellent results have been obtained in the case of superficial cancers of the skin (those which are torpid and of slow evolution), in the case of erectile tumors, of pruriginous and eczematous dermatites, in the depilation and decoloration of *naevi*, in the destruction of those red birth-marks known as winestains, and in highly sanguine tumors.

It should be especially remarked that the doctors who originated this system of therapeutics lay stress on the circumstance that the radium treatment should be regarded as an adjunct to surgery—"a process most often designed to accompany others."

Aside from these dermatological cures the use of radium has been chiefly instrumental in ameliorating certain cases of nerve affections, especially sciatica, "shingles," etc.

Radium has been utilized by injecting one of its salts into the organism. It becomes fixed and the process of elimination is very slow, consuming over a year. This form of modification is said by Molinié to be as yet little known and not used in medical practice. Another method of making use of the emanations is by drinking or bathing in water which is either naturally or artificially radio-active. This property is not inherent in the water, but is acquired by its being in contact for a considerable period with radio-active earths. Gout and rheumatism are particularly benefitted by such waters. It is this property of radio-activity (induced in the water by contact with radio-active substances and strictly temporary in character), which is now supposed to be responsible for the efficacy of various "mineral water in such afflictions."

At the baths in Kreuznach a simple apparatus has been devised for artificially inducing radio-activity in plain water by slowly passing it over earths known to be radio-active.

Action of Ultra-violet Rays on Vegetation

THE investigation of the action of ultra-violet rays on vegetable cells, especially those containing chlorophyll, is doubtless of great importance. Dr. J. Stoklasa, professor at the Techincal High School of Prague, in a recent paper gave a valuable contribution to our knowledge of the assimilation problem, and his results serve as the starting point in the investigation of the natural mode of assimilation of carbonic acid in cells containing chlorophyll. Stoklasa had observed that the action of ultra-violet rays on carbonic acid and hydrogen in the nascent state, in the presence of potassium hydroxide, determines a photosynthesis, the formaldehyde thus produced being condensed to sugar.

In continuing this line of research Dr. Stoklasa,[1] with several collaborators, examined in detail the action of ultra-violet rays on chlorophyll cells. Germinated and entirely intact grains of several plants (peas, maize, oats and barley) were introduced into moist sand and cultivated in the dark at a temperature of 20 deg. Cent. The etiolated plants thus developing are ten days afterwards divided into three groups: The first group is left in the dark room; the second is exposed directly to sunlight, and the third is exposed to a mercury lamp of 110 volts and 4 amperes fitted with a glass globe. After two hours' action of the ultra-violet rays these etiolated leaves are found to take a deep green coloration, whereas those exposed to sunlight still kept their etiolated yellow appearance. It required six hours for these leaves to take the same deep green coloration as those exposed to ultra-violet rays.

Prolonged etiolating in the dark room so reduces the vitality of the protoplasm that the ultra-violet rays are no longer capable of determining immediately a formation of chlorophyll. Experiments made on etiolated beet leaves under the action of ultra-violet rays go to show that even after only one hour's action, the leaves begin taking a marked green coloration, while two hours suffice to make their color a deep green. Leaves exposed at the same time to diffused daylight had hardly changed their yellow color. A striking fact is that leaves exposed to the mercury lamp, after having been cut and kept in water, are even a week afterward found to possess their old freshness, whereas those kept in diffused daylight were after three days almost completely withered.

Experiments made with the mercury lamp without any globe, that is to say, with ultra-violet rays at their full intensity, give practically identical results. The rays absorbed by glass thus seem to exert no influence on the formation of chlorophyll.

Further experiments are made by causing ultra-violet rays to act for one hour on the young green leaves of different plants. These leaves are found to remain quite intact, and after two hours' action to take a deep green hue. The chlorophyll of their cells undergoes no change. After four hours' exposure only those leaves which have been struck directly by ultra-violet rays are found to be dried up. However only the protoplasm of epidermal cells is altered, as seen by a brown coloration of the leaves on subsequent exposure to atmospheric oxygen.

A striking fact is that the flowers and leaves of hot-house plants are much more susceptible to the action of ultra-violet rays than those growing in the open air.

The mykoplasm of bacteria is extremely susceptible to the influence of ultra-violet rays. Eight to ten seconds' direct action at 10 centimeters distant kills a culture of nitrogenous bacteria, whereas the rays traversing a sheet of mica are, even after five minutes' action, incapable of killing these bacteria.

[1] Centralblatt für Bakteriologie, etc., II., vol. 31, 1911.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Will-o'-the-wisp

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In SUPPLEMENT No. 1907, pages 47 and 48, I notice a paper by Charles Fitzhugh Talman on "The Elusive Will-o'-the-Wisp," and in this connection it occurs to me to call attention to a cause of this phenomenon not referred to by the writer of the above paper, I mean the infection of certain species of midges (Chironomids) with a species of photogenic bacteria pathogenic to them, as observed by Tarnani (*Revue russe Entomologique*, 1908, vol. 8, pp. 87 and 88) and by Issatschenko (*Bulletin de Jardin Imperial Botanique*, St. Petersburg, 1911, vol. 11, pp. 31 to 43); other references are given by these authors. I have been told that the English "Will-o'-the-Wisp" is also due to midges. Although in the course of my observations on luminous organisms I have looked earnestly for it, I have never been favored with the sight of this phenomenon.

So far as a chemical explanation of the phenomenon is concerned, it appears from the recent work of Delepine (*Comptes Rendus*, Academie des Sciences, Paris, 1912, vol. 154, pp. 1171 to 1173) that there is a large series of compounds containing sulphur and carbon or sulphur and phosphorus which oxidize slowly in the air, giving off luminous clouds, and should any compounds of this nature be formed during the decomposition of organic matter under certain circumstances, they might give rise to the phenomenon.

The fact that these compounds described by Delepine all contain sulphur is of interest when considered in connection with the note on the "phosphorescence" of sulphur, on the last page of SUPPLEMENT No. 1908. This suggests another curious phenomenon which does not appear to be generally known—the luminous incomplete combustion of ether vapor. This seems to have been discovered by Sir Humphrey Davy and is described by Perkin (*Journal of the Chemical Society*, London, vol. 41, p. 363). It may be shown, by allowing an electric hot-plate to heat up to 260 to 300 deg. Cent., and then projecting onto it a fine stream of ether, say from a small wash-bottle. A distinct pale blue flame will be seen to arise from the plate, and this will be maintained as long as the ether is supplied. It will be found impossible to ignite paper or other combustible materials by this flame, and if some ether be ignited with a match, by way of comparison, it will be seen that the flames are quite different. The experiment must be done in a room as dark as it is possible to make it, as the flame is very pale; the eyes should be allowed to accustom themselves to the dark before attempting to observe the flame. It is also essential that the room be fairly large, or that it have very good ventilation, as the ether under these conditions forms aldehydes whose vapors are very irritating, and the accumulation of the ether vapor itself may become serious. Paraffin and some other substances are also said to show this phenomenon. This action seems hardly to come under the classification of Chemiluminescence, but is probably more nearly related to the conditions which produce the blue color in the inner cone of the Bunsen flame.

F. ALEX. MCDERMOTT.

University of Pittsburgh.

[As some of our readers may wish to perform the experiment here described, it seems desirable to remind them of the excessive inflammability of ether and ether vapor. Persons inexperienced in the handling of such inflammable liquids are strongly advised not to attempt the experiment except in the presence of some responsible and experienced person.—EDITOR.]

Water Vapor and Fire in the Second Century B.C.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

Referring to the article on "The Effect of Water Vapor in Promoting Combustion," in the SCIENTIFIC AMERICAN SUPPLEMENT of May 4th, perhaps it may be interesting to your readers to know that the presence of water in adding to the fierceness of fire was known to the Aryans of India ages ago, as the following quotation from the Laws of Manu, given in Max Müller's "Chips from a German Workshop," will show:

"As fire with augmented force burns up even humid trees, thus, he who well knows the Veda burns out the taint of sin in his soul which arose from evil works." (Vol. II, p. 303.)

The Laws of Manu are considered by some authorities to date from the second or third century B. C., while others give them a far greater antiquity.

Los Angeles, Cal. A. K. VENNING.

Engineering Notes

Cork Facing for Pulleys.—A certain amount of loss through slipping occurs in all power transmission by belt and pulleys. This is often reduced by applying rosin to the face of the pulley, a practice which, however, is destructive to belts. A suggestion made in a recent number of *Cosmos* is to face the pulleys with cork.

Some Remarkable Color Changes in Plants.—The flowers of *Erodium gruinum* and *Erodium ciconium* display a peculiar color reaction to temperature changes. On cold days the flowers are dark blue, on hot days wine red. If the flowers are suddenly exposed to a temperature of 104 to 108 deg. Fahr., the blue color is almost instantly changed to red, which gradually becomes paler and paler. As soon as the flowers are returned to normal conditions the blue color returns. This matter has been made the object of an investigation, reported on in the *Zeitschrift für Botanik*, by Prof. H. Fitting.

Ferries in Rotterdam.—Among the interesting features of the Rotterdam port, besides the huge floating cranes known from their shapes as Besin (60 tons) and Giraffe (25 tons) are to be noted the steam ferry barges which cross the Meuse River at all times and carry a large load of passengers and heavy wagons. Such ferries can take 16 loaded power wagons at a time. No rudders are used, but four propellers instead, two in front and two in the rear for propelling and steering at the same time. The decks can be raised and lowered so that in spite of the tides, they are always on a level with the piers. Such differences in level are as much as 8 feet in this port, so that the vertical movement of the decks had to be made considerable.

Constantza, a New Roumanian Port.—The new port of Constantza, Roumania, is one of the most modern on the Black Sea, and its grain storehouses are perhaps the largest in Europe at present. The inner port has an area of 150 acres and is protected by jetties. At the entrance are two lighthouses. The fore port has 35 acres surface. Noteworthy are the grain elevators built of reinforced concrete, each of which has 4,000 square yards surface and is 170 feet high. A special quarter of the port is laid out for petroleum and other oils, and there are 4 pipe lines for benzine, refined oil and residues. A whole train of tank cars can be emptied in this way in a very short time into 25 large storage tanks. Owing to the great draught of the petroleum boats, this part of the port is made as deep as 30 feet.

Carbonization of Lubricating Oils.—C. E. Waters sums up the results of an investigation carried out at the Bureau of Standards as follows: It has been shown that the addition of various oils and other substances to a straight mineral oil affects the amount of carbonization, as measured by the percentage of precipitate thrown out by petroleum ether, in various ways. Lubricants containing soap in quantity, rosin and asphalt, or which have been exposed to the action of sunlight and air, are to be avoided. One must not conclude, however, from the low results obtained with mixtures containing tallow, lard oil, etc., that the addition of these oils is to be recommended. The presence of the fatty acids resulting from the decomposition of the oils may greatly increase the corrosion of the cylinder and in actual practice cause as much carbonization as the direct addition of ferric oxide would do.

Drying Air for Blast Furnaces.—In a paper recently read before the Engineers' Society of Western Pennsylvania, Mr. Bruce Walter quoted the following interesting figures: A modern blast furnace requires about 40,000 cubic feet of free air per minute which is usually taken into the blowing engines directly from the engine room. Until recent years no attention was given to its condition as to temperature or moisture content. Consequently, under these conditions, 40,000 cubic feet does not mean a fixed quantity of oxygen delivered to the furnace but a widely varying quantity depending on its temperature and the quantity of water vapor which it contains. These variations will affect the weight of dry air delivered by the engines as much as 14 per cent as between winter and summer and frequently a change of 5 per cent occurs in a period of 24 hours. Such abrupt changes always make trouble for the furnace operator, causing the furnace to work irregularly and effecting changes in the grade of iron produced. But, while regularity is desirable, the main object of a dry blast plant is to eliminate the water vapor which, in itself, is such an undesirable element to introduce into the furnace. If the air contains 7 grains of moisture per cubic foot and the furnace is taking 40,000 cubic feet per minute, 40 pounds of water will be blown into the furnace each minute and one pound of coke will be consumed in the decomposition of each pound of water. This means that for each day that the above condition exists, a carload of coke is charged into the furnace which does nothing but decompose water vapor.

For Successful Commutation.—It is most important that the pitch of the brushes round the commutator should be set exactly right. A good way is to measure the circumference of the commutator with a steel tape, and divide the figure by the number of sets of brushes. Then multiply the figure by 2, 3, 4, etc., to get the distances of each row from the first row. By measuring from the first row, any cumulative errors which would creep in if each row was spaced from the one preceding it are avoided. Another way is to take a long strip of paper, pass it round the commutator, and divide it off in lengths corresponding to the distances between the rows of brushes by doubling the paper strip on itself. Then put the paper strip back on the commutator and fix the brushes to the marks.—*The Engineer.*

Street Car Trailers

IT is a matter of surprise that the street car trailer has not come into more extended use. In an article published in the SCIENTIFIC AMERICAN illustrating the new trailing cars which are in use in the city of Pittsburgh, it was shown that for a moderate increase in the power, there was a great increase in the carrying capacity for the same speed when a trailer was added to the motor car. The objections on the ground of interference with street vehicular traffic are valid; but they have been greatly overestimated. Certainly they do not compare with the great increase in capacity which follows the complete equipment of a line with trailers.

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